THE ENGINEER

JULY 22, 1955

Centenary of London's Main Drainage

AN exhibition on the occasion of the centenary of London's main drainage system has been held this week by the London County Council at the County Hall, and is open for the last time to-day. The history and functioning of the Council's main drainage service is explained at the exhibition, and various models and equipment are to be seen. The five main pumping stations of the system—Abbey Mills, E.5; Deptford, S.E.10; Falcon Brook, S.W.11; Hammersmith, W.6; and Western, S.W.1, have also been open to the public throughout the week. Conditions had become so intolerable in the metropolitan area in the eighteen-forties and fifties that, after many years of public contention, to say nothing of epidemics of cholera, the Metropolitan Board of Works was set up by the Government. The Board's primary duty was that of maintaining the main sewers and constructing works to prevent sewage entering the Thames within the London area. The engineer of the Board—Joseph Bazalgette (who was later knighted) prepared a scheme in 1856 for three intercepting sewers on the north side of the river and two on the south side, traversing London from west to east, and leading to outfall sewers discharging to the river at Barking on the north side and at Crossness on the southern side. It was necessary to have an Act of Parliament, in 1858, before these works could be built, and they were not completed until 1875. Since then considerable enlargements have been made to the main sewer network, throughout the years, and purification works have been built at the outfalls. The northern outfall works and Deptford pumping station were completed in 1864, and the southern outfall works and pumping station, with its four large beam engines, in 1865. Abbey Mills pumping station was opened in 1868, and the Western pumping station in 1875. An account of recent work at the North outfall, where a large battery of primary sedimentation tanks has just been completed, and a secondary treatment plant is under construction, was given in our recent issue of July 1st. These works form part of a £14,000,000 programme of improvements which the L.C.C. is carrying out at both outfalls.

Standardisation and Productivity

A NEW pamphlet entitled "Standardisation —An Aid to Productivity," has just been published by the British Productivity Council. The pamphlet focuses attention on the need to cut out waste in industry and indicates some of the advantages to be gained from standardisation, particularly with relation to the medium and small producer and from the point of view of the consumer. Standardisation of objects rather than workshop practice is the concern of the pamphlet, which deals with material specifications, dimensions, quality and codes of practice and defines the ideal as the maximum of variety of end product with the minimum variety of components. An example shows the reductions in types of tools and materials effected by a company by applying the principle of standardisation and without affecting the end product. A model appreciation which may be made by the management of firms intending to adopt a policy of standardisation is set out in detail, and it is emphasised that any such policy must be fully supported by the management. Another important point made is that those in charge of the scheme must have sufficient authority to ensure that conditions are applied. Particular stress is laid upon the questions which a firm might ask itself upon the correctness of the degree of standardisation adopted and certain examples of this form of self-examination are quoted. The international and export aspects of standardisation are discussed and also the need for the content of British standards to be available in countries engaged in formulating new standards. Some notes are given in the pamphlet upon the work of the British Standards Institution and how standards are drawn up together with details about how firms can keep in touch with the work of the Institution and even participate in it.

Report of the National Institute of Agricultural Engineering

THE annual report of the National Institute of Agricultural Engineering and the Scottish Machinery Testing Station for the year ended September 30, 1954, has just been received. In the agricultural testing department the introduction of a small laboratory workshop was found to be of considerable benefit in all aspects of the work. At the time the report was prepared this department had fourteen kinds of machines under study or awaiting investigation, including combine harvesters, potato harvesters, hammer mills, balers, ploughs, sprayers, dusters, sugar beet harvesters, cultivators, &c. The work in the mechanical engineering department consisted in the main of a continuation of lines followed previously. In farm trials by the tractor testing section of this department the pilot scheme using one model from each of the two leading tractor makers went ahead. By the end of the year a full year's record had been obtained for most of the seven tractors used from each of the two models selected for the trials. In a final test the tractors were to be tried in the state they had reached and again after some adjustment by test personnel. Means of testing tractors under tropical conditions of heat, dust and mud, such as are met in a paddy field, were also being developed by this section. In the notes dealing with tractor research and development reference is made to a report published describing a single-wheel tester and the experimental tractor with hydraulic transmission. Reference is also made to projected development work on a self-propelled combine harvester incorporating endless belt threshing and some of the problems involved. A large part of the report of the Scottish Machinery Testing Station deals with the subject of land reclamation and improvement under three main headings—reclamation of derelict and virgin land, cultivation of stony ground and bracken control and eradication. This Station also developed a number of special instruments to determine the behaviour of implements and machines on sloping ground.

Opening of Yarkon-Negev Pipeline

ON Tuesday, July 19th, the Yarkon-Negev water pipeline was officially opened by the President of Israel, Mr. Ben-Zvi. The construction of the 108km pipeline, which consists of 66in diameter prestressed concrete sections, was commenced two-and-a-half years ago, and it is anticipated that it will be in full operation next spring. It will then deliver water at an annual rate of 100 million cubic metres from the springs at Rosh Haayin, at the head of the Yarkon River. These springs are situated only about 16m above sea level, whereas the area to be irrigated is at 100m to 150m above sea level. Three smaller and three major pumping stations, of a total capacity of 30,000 h.p., have been constructed, which pump the water to a 200,000 cubic metre reservoir at Tekumah, and a 48in pipeline will take the water from there to another reservoir near Magen. Work on a second similar line has already begun and when this comes into operation about two-thirds of the waters of the Yarkon, which total 200 million cubic metres annually, will be diverted to the Negev, the remainder supplying Tel-Aviv.

George Ellison

WE have learned with regret that Mr. George Ellison, who was in his eighty-third year, has died at Rheinfelden, Switzerland. Mr. Ellison was chairman of the switchgear works of George Ellison, Ltd., of Tufnol, Ltd., and of the iron-foundry of Alfred Ellison, Ltd. George Ellison was educated at Manchester Grammar School. After serving an apprenticeship with the Oerlikon Engineering Company at Oerlikon, Switzerland, he completed a course of study at Winterthur University. In 1893 he went to America and worked with the Westinghouse Company as designer and chief draughtsman and later with the Western Electric Company in Pittsburgh, New York and Chicago. On returning to Europe in 1898 he set up in business in Paris on his own account, making and selling electric switchgear, with the help and encouragement of his father, Thomas Wilson Ellison, who had established his own machine tool business in Paris. The new switchgear business in Paris prospered and grew rapidly. Then in 1906 the business was transferred to Birmingham, where it quickly outgrew its accommodation, and in 1916 the original buildings of the present factory were built at Perry Barr. In 1929 Mr. Ellison founded the associated company, Ellison Insulations, Ltd., which later became Tufnol, Ltd., and in 1946 the foundry of Alfred Ellison, Ltd., was brought into the Ellison group of companies. Mr. Ellison took a keen interest in industrial welfare, and was a life governor of the University of Birmingham.

Lloyd's Register of Shipping Quarterly Returns

THE shipbuilding returns for the quarter ended June 30, 1955, have been published by Lloyd's Register of Shipping; they show that steamships and motorships under construction totalled 338 ships of 2,081,534 tons, 62,612 tons less than the preceding quarter, of which 108 ships of 575,666 tons were fitting out, while 230 of 1,505,868 tons were still to be launched. During the quarter the ships commenced totalled 71 of 293,977 tons, those launched amounted to 86 of 417,547 tons, and 69 ships of 371,348 tons were completed. Some 101 ships of 764,506 tons, or 36·7 per cent, were for registration abroad. Oil tankers at 80 ships of 1,011,081 tons represented a decrease of 93,287 tons, compared with the previous quarter, and 48·6 per cent of the tonnage under construction. Work in hand abroad, excluding China, Poland and Russia, amounted to 1011 ships, representing 4,019,000 tons and an increase of 199,959 tons over the March quarter. There were 373 ships of 1,136,256 tons commenced, 301 ships of 947,437 tons launched and 302 ships of 899,135 tons completed during the quarter. Ships for registration elsewhere than in the country of building increased by 183,566 tons to 1,615,336 tons, or 40·2 per cent of the total under construction abroad. Oil tankers represented 48·4 per cent of the tonnage being built—149 ships of 1,943,260 tons, a decrease of 55,629 tons since March. The size of ships under construction included 113 ships between 6000 to 8000 tons, 65 ships between 8000 to 10,000 tons, 110 ships between 10,000 to 15,000 tons, 42 ships between 15,000 to 20,000 tons, 59 ships between 20,000 to 30,000 tons each, and 3 ships at between 30,000 and 32,000 tons. In Great Britain and Northern Ireland the total under construction included: steamships 1,227,638 tons, motorships 853,896 tons, the corresponding totals for construction abroad being 1,646,265 tons and 2,373,735 tons. Of the total world construction 3,742,172 tons, or 61·3 per cent, were under the inspection of Lloyd's Register.

Factors in the Working of a High-Speed Train Service

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

No. II—(*Concluded from page 68, July 15th*)

In recent years much work has been done towards the scientific testing of locomotives, and the interpretation of test results in terms of haulage capacity in different sets of running conditions. The first practical application of this work in the improvement of express train services was seen in June, 1954, when considerable accelerations of many trains took place in the Western Region of British Railways. In this article the author comments upon the first six months' working of these trains, and touches upon the operational difficulties encountered. These difficulties are liable to occur equally with newer forms of motive power and with steam.

IT will now be of interest to examine some actual examples of running, to note the detailed application of some points brought out generally in the preceding discussion. Table VI includes some details of two runs with the up "Bristolian." The first of the two was made on a day of exceedingly rough weather, on which the train passed Swindon on time, picked up 3 min out of the 4 min "recovery" included between Swindon and Didcot, and then used this margin in hand to avoid having to press the engine unduly to combat the effects of the high wind which was felt most keenly east of Didcot. The train was still slightly ahead of time at Southall, and the second 4 min recovery margin was enough to offset the signal delay outside Paddington. On the second run there was one slight reduction of speed over a junction newly relaid. The reduction was from 82 m.p.h. to 57 m.p.h. and cost about a minute in running. Elsewhere the performance was continuously at maximum recovery standards, and the train reached Paddington 9 min early. On this journey the average speed over the 55½ miles between posts 66½ and 11 was exactly 85 m.p.h.

I was privileged to make a journey on the footplate with this train, and with no checks of any kind until the immediate environs of Paddington the driver chose to let his recovery margin gradually slip away. At Didcot he was 2½ min ahead of time, and at Slough exactly on time. Passing Westbourne Park in 98 min from Bristol we had a comfortable 4 min in hand, but through adverse signals the actual arrival was a minute late. This run showed an engine performance about midway between the "service" time, of 105 min for the 117·6 miles, and the maximum recovery equivalent of 97 min. The following details may be quoted :—

TABLE V—*The Up "Bristolian"*

Load : Seven coaches, 234 tons tare, 250 tons full.	
Engine : "King" class 4-6-0, No. 6000, with high superheat boiler and improved draughting.	
Actual time of trip	106 min 5 sec
Net running time	101 min
Net average speed	69·8 m.p.h.
Average speed, posts 100 to 2 (98 miles) ...	78·2 m.p.h.
Maximum speed	86 m.p.h.
Water consumption (tender gauge)	2,950 gallons
Evaporation (approximately)	17,000 lb per hour

The evaporation as read from the tender gauge appears to be very low; but the method of working with soft coal probably accounts for this. A large fire is built up before the start, and appreciable firing ceased a full 40 miles before the journey's end. Conditions in the firebox were totally different at beginning and end of the run. Thus the fireman had an easier task than the demands of this fast schedule would lead one to believe.

Except for the climbing of Filton bank the engine was worked throughout with the cut-off at 18 per cent, and the variations in power output required were made by slight adjustments of the regulator. Such adjustments ranged from the first port full open to the main valve little more than "cracked." The steaming was very free, but although pressure was kept constantly between 240 lb and 250 lb per square inch the safety valves were not permitted to blow off to a greater extent than the "sizzling" which is possible with direct loaded valves.

The Bristol enginemen working the up "Bristolian" return with the 7.50 p.m., another sharply timed train, and details of two runs with this are given in Table VII. The allowance of 34½ min start to stop for the 36 miles from Paddington to Reading is followed by a 4 min recovery margin onwards to Didcot, and although the overall allowance of 56½ min start to stop from Reading to Chippenham (58 min) is fast, it is easier to observe than the initial booking. When there are no engineering slacks to be observed there is a temptation to drivers to drop 1 min or 1½ min to Reading, in the knowledge that such time can easily be recovered afterwards. The two runs in Table VII show characteristic work on this train; the first exemplifies time keeping on the first stage, and running up to maximum recovery standard on the second, while the second run shows a slight loss of time to Reading, and a recovery afterwards to the extent of passing Swindon 2½ min early. On this latter run I was on the footplate, and the engine working was the same on both sections—18 per cent cut-off from Acton to Milepost 34, and again from Tilehurst throughout to Swindon. This was a logical method of working, but it resulted in the train being late in its advertised arrival time at Reading.

On this working the engine is prepared and brought into Paddington by relief men, and the Bristol crew that have come up with the "Bristolian" take over in the station. Because the train happens to be a light one the duty facing the engine is not always appreciated by the relief enginemen, and I have known cases where the fire was not adequately burned through, and thus compelled an easy start while the regular fireman was getting things into shape. On my run with engine 5063, however, the job had been well done, and we were able to make a good start. It was noticeable that the water consumption between Paddington and Chippenham on this journey was 2950 gallons; this was equivalent to an evaporation of approximately 20,000 lb per hour—considerably more than that on the up "Bristolian" with engine No. 6000 (Table V), though for reasons already stated the "Bristolian" figure is undoubtedly low. The maximum recovery equivalent for the 7.50 p.m. as between Reading and Chippenham as given in the working timetable does not, by a long way, represent the maximum capacity of the "Castle" class locomotives on this duty. The schedule requires an average speed of 69 m.p.h. up the gradual rise from Didcot to Swindon, but I have seen this speed increased to 71·7 and 73 m.p.h. with "Castle" class engines in recent weeks, and

TABLE VI—*The Up "Bristolian"*

Engine No. ("King" class) / Load, tons full / Weather			6024 250 Southerly gale		6015 250 Calm	
Distance, miles		Schedule, min	Actual, min sec	Average speed, m.p.h.	Actual, min sec	Average speed, m.p.h.
0·0	Bristol	0	0 00	—	0 00	—
4·8	Filton Junction	8½	8 32	33·8	8 16	34·9
7·7	Winterbourne	—	12 09	48·1	11 27	54·5
17·6	Badminton	21½	21 29	63·7	20 12	67·8
27·9	Little Somerford	—	29 12	80·5	27 40	83·1
34·7	Wootton Bassett*	34	34 30	77·0	33 12	73·9
40·3	Swindon	39	39 04	73·7	38 03	69·3
					Slight permanent way	
51·1	Uffington	—	46 59	81·8	46 47	74·1
64·5	Didcot	59½	56 29	84·6	56 13	85·2
81·6	Reading	71½	69 44	77·4	68 16	85·1
99·1	Slough	84½	83 08	78·3	80 41	84·6
108·5	Southall	91	90 28	76·9	87 32	82·3
116·4	Westbourne Park	—	96 40	76·4	93 46	75·9
			Signal check			
117·6	Paddington	105	104 20	—	96 12	—
	Net time (minutes)		99½		95	
	Net average speed (start to stop) m.p.h.		71		74·4	

* Permanent speed restriction to 60 m.p.h.

NOTE.—4 min recovery time in schedule, Swindon to Didcot, and Southall to Paddington.

TABLE VII—7.50 *p.m. Paddington-Chippenham*

Engine No. ("Castle" class) / Load, tons full			5057 265		5063 265	
Distance, miles		Schedule, min	Actual, min sec	Average speed, m.p.h.	Actual, min sec	Average speed, m.p.h.
0·0	Paddington	0	0 00	—	0 00	—
4·3	Acton	—	6 42	38·5	6 49	37·9
9·1	Southall	11½	11 16	63·2	11 44	58·6
18·5	Slough	19	18 58	73·2	20 08	67·2
31·0	Twyford	29½	29 01	74·6	30 52	69·7
36·0	Reading	34½	33 38	—	35 52	—
5·5	Pangbourne	—	7 33	43·7	7 17	45·3
17·1	Didcot	21½	17 51	67·5	17 36	67·5
30·5	Uffington	—	29 42	67·8	29 20	68·5
41·3	Swindon	42½	39 12	68·3	39 03	66·7
46·9	Wootton Bassett	—	44 07	68·4	43 53	69·6
					Signal check	
56·6	Langley Crossing	—	51 55	74·6	53 43	—
58·0	Chippenham	56½	53 28	—	55 38	—

NOTE.—4 min recovery time : Reading to Didcot.

an actual start-to-stop time of 51 min made from Reading to Chippenham.

The 7.45 a.m. express from Bristol to Paddington was worked for about a fortnight in the early autumn of 1954 by the Brown Boveri gas turbine locomotive No. 18,000, and a run behind this machine on which the train got an unusually clear road is given in Table VIII. The immediate start from Chippenham, as usual with this locomotive, was very slow, and further delay was caused by the dead slowing near Shrivenham, for permanent way work. Then the road was obtained and a distance of 62 miles were covered at an average speed of 74·3 m.p.h.

TABLE VIII—7.45 *a.m. Bristol-Paddington*

Engine : No. 18,000 (gas turbine).
Load : 420 tons to Didcot, 380 tons to Paddington.

Distance, miles		Actual time min sec	Average speed, m.p.h.
0·0	Chippenham	0 00	—
16·7	Swindon	18 53	—
		Permanent way slack	
30·1	Challow	34 53	—
40·9	Didcot	43 28	75·5
52·5	Pangbourne	52 29	77·4
58·0	Reading	56 40	78·8
69·8	Maidenhead	66 20	73·6
75·5	Slough	71 00	73·4
84·9	Southall	78 50	72·1
92·0	Milepost 2	84 52	70·9
94·0	Paddington	89 18	—

The running of the 9 a.m. express from Bristol to Paddington has been the most successful of any trains observed, other than the "Bristolian," the working of which is very carefully watched. The excellent running of the 9 a.m. up, with heavy loads, will already have been appreciated from the summary details in Table III, and now more detailed reference is made (Table IX) to a very good run with a load one coach in excess of the normal. The immediate start from Bath was brisk, but the 3-mile rise at 1 in 124–100 through Box tunnel kept the average from the start down to 43·5 m.p.h. until Chippenham had been passed. Then the 92 miles between Posts 94 and 2 were covered in 83½ min, an average speed of 66·2 m.p.h. inclusive of the severe check near Shrivenham. Taking this latter into account the net average was 69·4 m.p.h. The sustained speed on level track between Maidenhead and Slough was 76 m.p.h. with the load of 440 tons. At this point the estimated drawbar horsepower was 1060, while the average sustained for 1½ hours was 850. These are approximately equivalent to steam rates of 28,000 lb and 22,000 lb of steam per hour. The former is probably beyond the limit of continuous steaming for "Castle," but the frequency with which high speeds are attained on the level road east of Swindon with trains in excess of 400 tons is a feature of present-day running. Some further examples of this are quoted in Table X.

"Castle" class locomotive hauling the Pembroke coast express

TABLE X—"*Castle*" *Speed*

Engine No.	Load, tons, gross	Gradient 1 in	Sustained speed, m.p.h.	D.H.P. corrected for gradient	Approximate steam rate lb per hour
5057	400	754 F	82	760	26,000
7034	435	754 F	77	720	23,000
5077	475	754 F	72	650	21,000

The corresponding down express leaving Paddington at 5.5 p.m. and having the same overall time allowance for the 106·9 miles to Bath is not able to show such good results. There is a very close timetable clearance in front of it at Chippenham, due to the running of the 6.33 p.m. local train for the Trowbridge line, which cannot readily be timed to leave earlier due to making a connection with an up train due at Chippenham at 6.29 p.m. The local is due to pass Thingley Junction and clear the main line at 6.38, and the express is booked 6.41½ p.m. through Chippenham. In actual practice this means that if the express approaches as much as a single minute ahead of time adverse signals are sighted. On this account drivers are inclined to hold their engines in until Swindon has been passed, often running 1 min to 2 min late at this point, and then to make a dash for it. One of the most vigorous runs with this train (engine 5027 and 410 tons) showed an average speed of 62·2 m.p.h. over the gradually rising 68·2 miles from Southall to Swindon, equivalent to a drawbar horsepower of 740 sustained over this length ; but in consequence Swindon was passed 3½ min early, and the train was practically stopped at Chippenham.

Last for consideration are the Torbay expresses, booked to cover the 173·5 miles between Paddington and Exeter in 175 min start to stop in each direction with a rostered load of 350 tons tare. While the accelerated trains on the Bristol service make runs of two hours, or slightly over, the Torbay expresses involve a through working of more than four hours, for most of which the effort is sustained at high rates of evaporation. The up train is a particularly severe duty. Before starting away on the high-speed run from Exeter to Paddington the locomotive has put in 75 min of intermittent work, including four intermediate stops, and some very hard collar work over the heavy gradients of the Torquay branch. Mismanagement of the engine here could lead to serious troubles on the 173½-mile non-stop run from Exeter to London, especially when it is realised that the start from Kingswear entails 8 min of heavy pounding up the 1 in 66 to 75 gradients of Churston bank. There is no gradual warming up to the job ; with full load it is a case of 40 per cent cut-off and full regulator, and speed down to 22 or 23 m.p.h. before the crest of the bank is reached. Here, and in the punishing start up the 1½ miles of 1 in 55–73 out of Torquay the immunity from slipping troubles that is characteristic of the Great Western 4–6–0s is a great help to the drivers and firemen ; for a bad bout of slipping on such inclines could well tear the fire to such an extent as to prejudice steaming for the rest of the journey.

On a trip I was privileged to make on engine No. 5059 the early stages of the journey were competently managed, though one noticed the relatively high coal and water consumption occasioned by the intermittent character of the work : 34 miles, in a journey time of 71 min, at a water consumption of approximately 1400 gallons. At Exeter, due to the large number of passengers travelling, an extra coach was added, bringing the tare load up to 387 tons, and the gross to fully 425 tons behind the tender. The run may be summarised as shown in Table XI.

Unlike the Bristol runs, there was considerable fluctuation of speed *en route*, due to the stiff intermediate gradients. Apart from the bank from Castle Cary, the lowest

TABLE IX—9.19 *a.m. Express : Bath to Paddington*

Load : 12 coaches, 409 tons tare, 440 tons full. Engine : 5077 ("Castle" class).

Distance, miles		Schedule, min	Actual, min sec	Average speed, m.p.h.	Gradients
0·0	Bath...	0	0 00	—	Level
1·1	Milepost 105½	—	2 55	—	Rising 1 in 900
5·0	Box	—	7 56	46·8	Rising 1 in 110
7·9	Milepost 99	—	12 01	42·6	Falling 1 in 660
12·9	Chippenham	—	17 42	52·8	
19·2	Dauntsey	—	23 09	69·4	
21·6	Incline Box	—	25 35	59·1	
29·6	Swindon	32½	33 50	58·2	
35·3	Shrivenham	—	39 04	65·2	
			Permanent way check*		Level on average
40·4	Uffington	—	47 05	38·4	
46·5	Wantage Road	—	52 26	68·4	
53·8	Didcot	56½	58 12	76·1	
62·1	Goring	—	64 58	74·0	
			slack†		
70·9	Reading	70½	72 29	70·3	
82·7	Maidenhead	80½	82 10	73·1	
88·4	Slough	85½	86 43	75·3	Falling about 1 in 2000
97·8	Southall	94	94 40	71·0	
104·9	Milepost 2	—	101 18	64·2	
106·9	Paddington	109	104 52	—	

* 5 m.p.h. over culvert.
† Eased to 65 m.p.h. at water troughs.

speed, other than for signal checks, was 40 m.p.h. at Whitehall summit, followed, 5 min later, by the highest speed of the journey, 86 m.p.h. The effort was roughly divided into three main spells of hard running, as follows : Exeter (start) to passing Charlton Mackrell, 51·3 miles in 51½ min ; Brewham Box to Savernake, 38·2 miles in 36¼ min ; Reading (pass slowly) to Milepost 2, 34 miles in 30¾ min.

This accounts for 123·5 miles of the journey, during which time the regulator was practically full open, and the engine being steamed on cut-offs mostly at 17 per cent or more. The 16-mile stretch from Charlton Mackrell to Brewham was subjected to delays arising from the engine failure on the preceding train, while the 34-mile length down the Kennet Valley from Savernake to Reading included the careful observation of three permanent speed restrictions—to 50 m.p.h. at Grafton Junction and to 60 m.p.h. at both Hungerford and Midgham. These were followed by a signal check just preceding the slack through Reading. Between the permanent restrictions the engine was put to it vigorously and speed was quickly worked up into the "seventies." The running, as compared with times laid down, was as follows (Table XII) :—

TABLE XI

Length of run	173·5 miles
Actual time (overall)	183 min
Actual running time	177¼ min
Net running time	167 min
Net average speed	62·4 p.m.h.
Water consumed	5,600 gallons
Evaporation (approximate average)	18,500 lb per hour

TABLE XII

Distance miles		Booked time, min	Actual time, min	Net time, min
0·0	Exeter	0	0	0
19·9	Whitehall Box	24½	25½	25½
30·8	Taunton	32½	34	34
—		—	check	—
58·4	Castle Cary	60	67½	57½
—		—	check	—
71·2	Blatchbridge Junction ...	73	86½	72½
78·9	Heywood Road Junction	79½	92½	78½
92·4	Patney	92	105½	91½
103·4	Savernake	102½	116½	102½
107·1	Bedwyn	110	119½	105½
120·4	Newbury...	121	131	117
—		—	check	—
137·5	Reading	136½	148½	132½
149·3	Maidenhead	147½	159½	143½
155·0	Slough	152	164½	148½
164·4	Southall	160	173½	157½
173·5	Paddington	175	183	167

NOTE.—4 min recovery time Savernake-Bedwyn.
4 min recovery time Southall-Paddington.

The work of the locomotive was thus fully up to maximum recovery standard, despite the excess of 37 tons in the tare train load. The engine concerned, "Castle" class 4–6–0 No. 5059, "Earl St. Aldwyn," has the improved draughting, but retains the original low-superheat boiler and hydrostatic lubricator. The steaming throughout was very free and the performance generally excellent.

Although not regularly scheduled, some very fast running has been made with the "Ocean Mail Specials" from Plymouth during the past year. These trains are subject to varying departure times, and do not always get a clear road ; but on a recent occasion the 173·5 miles from passing Exeter slowly to arrival in Paddington took 179½ min, despite 26½ min lost by signal checks. The net time of 153 min over this length gave an average speed of 68 m.p.h., with a load of 250 tons, and "Castle" class engine No. 5016. On the uphill stretches the working was harder than on the "Torbay Express"—indeed, for more than half-an-hour on end the evaporation was roughly 22,000 lb per hour.

The standard of individual engine performance as revealed by these recordings is very high, but the overall performance given to the public, and as reflected in the punctuality of the trains leaves room for improvement and emphasises the need, so often expressed in THE ENGINEER, for improved methods of traffic regulation on heavily worked routes. Meanwhile the continuing confidence of the Western Region authorities in the ex-G.W.R. four-cylinder 4–6–0 locomotives is further emphasised by the introduction of many new fast trains in the 1955 summer timetable. They include a 62½ m.p.h. run between Paddington and Newport, a run at 63 m.p.h. from Oxford to Paddington, and the notable acceleration of the Cornish Riviera Express. With the remarkable engine performances, recorded in trials prior to the latter acceleration, I hope to deal in a future issue of THE ENGINEER.

Geophysical Prospecting

By ROLT HAMMOND, A.C.G.I., A.M.I.C.E.

No. I

DURING the last few years there has been a tremendous advance in the application of geophysical methods for surveying the nature and arrangement of strata, largely stimulated by the world-wide search for oil over vast areas of the earth's surface.

For many centuries the divining rod has been used for revealing minerals, the first published description of this being contained in Agricola's famous mining textbook, *De re Metallica*, of 1556. During the sixteenth century German miners introduced this device into Cornwall with the idea of reviving the mining industry there. Even in those days the practice of dowsing aroused fierce controversy, and to-day there are still some misguided, but enthusiastic, people who stoutly maintain that dowsing gives reliable and consistent results, yet there is no shred of scientific evidence to support the view that the divining rod is a geophysical instrument.

UNRELIABILITY OF DOWSING

It is relevant in this connection to refer to a very interesting reference to dowsing by that eminent authority, Mr. R. C. S. Walters, M.I.C.E., in his classic work *The Nation's Water Supply* (Ivor Nicholson and Watson, Ltd., London, 1936), in reference to the search for water, which is often more important than minerals in some regions. He describes a series of tests carried out in 1913 at Guildford, when seven dowsers were examined separately by seven leading authorities on water supply, three pieces of land being selected. The first was on water-bearing strata, a large sewer running through the plot and known only to the examining experts ; the second was a lawn hiding a reservoir through which water was flowing, and the third was a field about 100 yards wide and 250 yards long, with a very strong spring 15ft below the surface. This was discharging water at 50,000 gallons an hour, another fact known only to the experts.

The results speak for themselves. On the first site no diviner spotted the sewer ; on the second, only one diviner found water in the middle of the underground reservoir. On the third, only one diviner got near the hidden spring. The committee of experts, in their report, made the following statement : "... wherever sensitiveness to underground water may exist in certain persons, of which some evidence has been given, it is not sufficiently definite and trustworthy to be of much practical value. Moreover, the lack of agreement with each other shows that it is more a matter of personal mentality than any direct influence of the water. The diviners, as a rule, confine their attention to small streams of water, and as there are few places where these cannot be found, they may well show a large percentage of success."

MAGNETIC METHODS

The first scientific application to physical methods of prospecting was made during the seventeenth century, when the magnetic method was introduced. A magnetic survey may be undertaken to locate magnetite deposits, which have a greater magnetic susceptibility than the surrounding rocks in which they are enclosed. This is the oldest of all geophysical methods, and is based on the fact that a freely suspended magnetic needle will come to rest inclined to the horizontal at an angle known as the dip ; the north-seeking pole is attracted downwards in the northern hemisphere and the south-seeking pole in the southern hemisphere.

Similarly, a magnetic needle free to swing in a horizontal plane will come to rest in the direction of the lines of magnetic force in a given area, but this direction will not coincide with the geographical meridian, the angular difference being defined as the declination or variation. A very early instrument for measuring local changes in horizontal intensity was devised by Kohlrausch in 1871, but this was comparatively insensitive ; in 1880, an instrument was developed for measuring both horizontal intensity and dip. In 1915, a magnetic re-survey of the British Isles was undertaken by G. W. Walker, who designed a very simple portable variometer for measuring variations in the horizontal component.

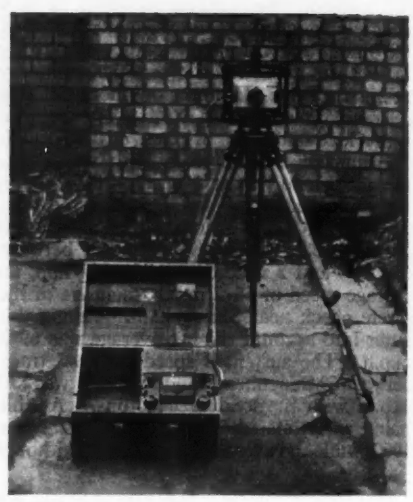


Fig. 1—Watts variometer for measurement of vertical magnetic component

Experience has proved that measurement of the vertical component provides more useful geological information than that of the horizontal component, and therefore to-day we find that wide use is made of instruments suitable for measuring the vertical component. In Fig. 1 we have the Watts vertical magnetic force variometer set up on its tripod, readings being made by observing on the scale of a telescope system the image of a standard index line, reflected by a mirror carried on a horizontally pivoted

magnet system; the difference between observations made at various stations is a measure of the difference in vertical magnetic force in those places. The scale has forty divisions, a deflection of one division having a value of 30 gamma, although the instrument can be adjusted from 10 gamma sensitivity upwards.

Three balance weights are carried by the magnet system, two on screwed rods fitted between the north and south ends of the magnet provide adjustment to compensate for temperature and latitude respectively; the third, screwed into the underside of the magnet casting, is the adjustment for sensitivity. Since temperature compensation of the magnet system is a function of the field for which it is balanced, adjustment of the magnet system is carried out in an artificial field equal to that of the area in which it is to be used. The method of compensation is by differential expansion of the two screwed rods carrying the balance weights.

These rods are generally of aluminium and Invar alloy in order to obtain the greatest differential expansion; for the northern hemisphere the aluminium rod is at the north and the Invar rod at the south, the arrangement being reversed for the southern hemisphere. Sensitivity of the instrument depends upon the excellence of the knife-edge suspension, consisting of a triangular shaped agate or quartz knife-edge, optically polished to an angle of 120 deg.

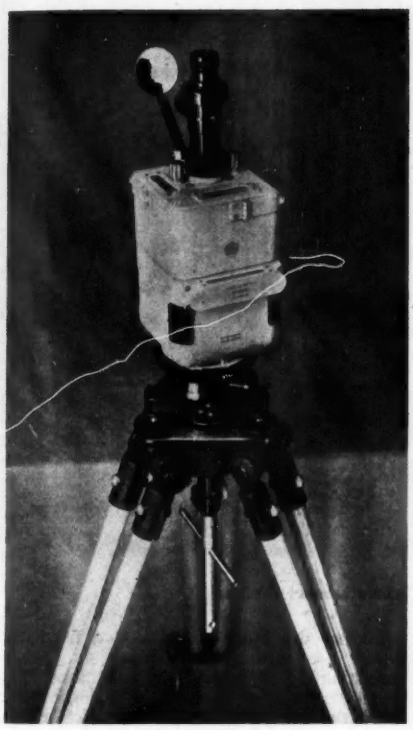


Fig. 2—Horizontal force variometer

A telescope of auto-collimating type is used, with an index diaphragm in a side tube illuminated by an adjustable mirror. An unsilvered parallel mirror in the telescope tube reflects the light through the objective to the mirror of the magnet system, from which it is returned again through the objective to a focus at the scale diaphragm below the eyepiece. A unique feature of this design is the doubling of the image produced by the unsilvered mirror, whereby a bold central index line is superimposed on the scale and a fine subsidiary index line on each side of it. Separation of the index lines is equal to 10 scale divisions, their purpose being to extend the range of observation when the main index line has been deflected off the scale; it is therefore only necessary to add or subtract 10 to the observed reading, as the case may be. The scale is figured from zero to 4, and the whole observation is very simple.

Design of the horizontal force variometer (Fig. 2) is similar to that of the vertical force instrument, except that the magnet system is arranged vertically and swings in the plane of the meridian; the same adjustments for sensitivity and temperature compensation are provided. Since vertical arrangement of the magnet responds to the intensity of the horizontal component in the magnetic meridian, the instrument cannot be reversed through 180 deg., so that only one set of readings can be made at each station. Scale value is generally adjusted to give greater sensitivity than is usual with the vertical force instrument, and 20 to 25 gamma is recommended. Scale reading is not a true measure of the horizontal component, but is also influenced by the vertical component. Adjustment is therefore carried out by the makers in an artificial field which reproduces both horizontal and vertical components of the area in which the instrument is to be used.

In Fig. 3 we see the horizontal force variometer set up with the calibrating coil attached, this being a more precise method of checking the scale value of the instrument in the field than can be obtained with the use of auxiliary magnet constants. This method involves measurement of the deflection produced by a magnetic field of known intensity, by observing on a milliammeter the current passing through the coil. The coil system comprises a pair of similar coaxial coils separated by a distance equal to their radius; a magnetic field is produced along the axis, passing through the centre of the coils. Magnetic fields in the space between the coils can be calculated from the dimensions of the coils and the number of turns, and this is given as a constant for the coil, which is applied to the measured current.

The magnetic method of geophysical prospecting is claimed to be the most rapid and least costly available, and there are no topographical limitations to its application, as there are with the gravitational method. Moreover, it is not necessary to employ a highly trained specialist for field observations, and this means that a check survey can be rapidly carried out with a magnetic variometer to obtain a general idea of the main geological features of a given district.

A photographic recording apparatus is available for use with both the above instruments, and it is very useful for obtaining permanent records to accompany a report. It consists of a camera which automatically produces on a sensitive recording paper a continuous record of magnetic variations over a period of time. A datum line from which variations are measured is recorded, and a time signal at hourly intervals is marked as a line across the chart. Duration of recording is up to twelve hours. Range of swing of the magnet system recorded by the camera is nearly equal to the field of view of the variometer telescope, and the recording distance is such that 1in of paper represents 10 scale divisions of swing. Records can be read to an accuracy of 0·1 division by comparison with a specially graduated glass scale.

An optical lever of 63in is given a double fold inside the camera box by a system of mirrors, thereby making the unit as compact as possible. Light from an illuminated vertical slit in the camera is made to fall on the magnet mirror of the variometer after passing through a multi-reflection mirror system in the camera box, a lens of 63in focal length, and a 45 deg. reflector in the reflecting head. The slit image is reflected back by the magnet mirror practically along its own path and re-imaged by the lens into the camera aperture. The slit image then passes through a cylindrical lens which converges the light to a point on the sensitised recording paper. In a similar way, light falling on a second, fixed mirror in the reflecting head is reflected directly back to the camera to form a datum line from which variations are measured.

A very important detail of this camera is the removable, light-tight recording drum which allows the camera to be loaded in daylight. The drum is so designed that it cannot be loaded into the camera when the aperture is open, nor can it be withdrawn without closing the shutter. A clockwork driving mechanism rotates the recording drum, simultaneously providing a time base for the record by operating a flasher mechanism which marks hourly intervals as a line on the recording paper. The whole apparatus is light-tight and all components are made of non-magnetic materials. The variometer telescope is replaced by a reflecting head when the recording camera is used.

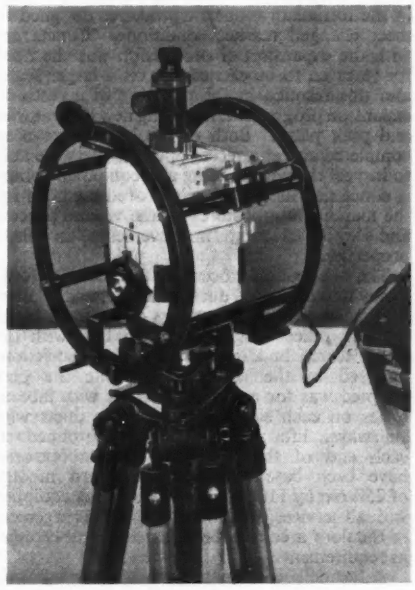


Fig. 3—Horizontal force variometer with coil attached

A comparatively recent development in geophysical prospecting is the airborne magnetometer, the object of which is to discover valuable mineral deposits over vast areas in minimum time. The new science of aerogeology should never be regarded as a substitute for detailed field work, but rather as the foundation upon which can be planned economical and efficient prospecting and field work.

(To be continued)

RUBBER DEVELOPMENT.—The Annual Report of the British Rubber Development Board for 1954 states that, during the year 108 stretches of "rubberised" roads were laid in the English speaking world, which included 47 put down in the U.S.A., 28 in the U.K., and a number in Malaya, South Africa, Australia and New Zealand. Promotional efforts for latex foam continued to meet with encouraging success, it is noted. During the year widespread trials were made in the U.K. with rubber rail pads. The pads, which are inserted between rail and sleeper, damp down vibration and are effective in cutting track maintenance costs. Development of the pads has resulted from co-operative work between the British Rubber Development Board, the British Rubber Producers' Research Association, and the British Transport Commission. Experimental work has also been carried out on rubber for ferrules, endposts, clip fastenings and other products for use on the permanent way.

Viscose Research Laboratory at Coventry

The expansion of the man-made fibre industry coupled with need to repair war damage to factories and build new ones and to evolve new processes to satisfy post-war market conditions, meant that present technical knowledge had to be fully applied to current production. To meet the situation Courtaulds, Ltd., planned a comprehensive research programme which necessitated the building of new laboratories and pilot plant buildings and the installation of up-to-date equipment. Part of this expansion programme is represented by the new Viscose Research Laboratory at Coventry.

IT was in 1904 that Courtaulds, Ltd., acquired the patent rights for the viscose process and in 1905 commenced commercial production of viscose rayon at Coventry. Research work necessary to technical development has been continuous over the years, but after the second world war it was essential to recondition existing plants and build new factories to resume production on an expanding scale. There was also the need to exploit the latest technical knowledge in the formulation of new processes designed to meet changed market conditions. Concurrent with the expansion of production was the need for research to be carried out on a larger scale, and this resulted in the planning of a research expansion programme, including new laboratories and pilot plant. Both of the latter have been completed and at a recent open day we were able to inspect the new building and equipment which is concerned mainly with improved methods for the manufacture of fibres by the viscose process and with effecting improvements in their properties.

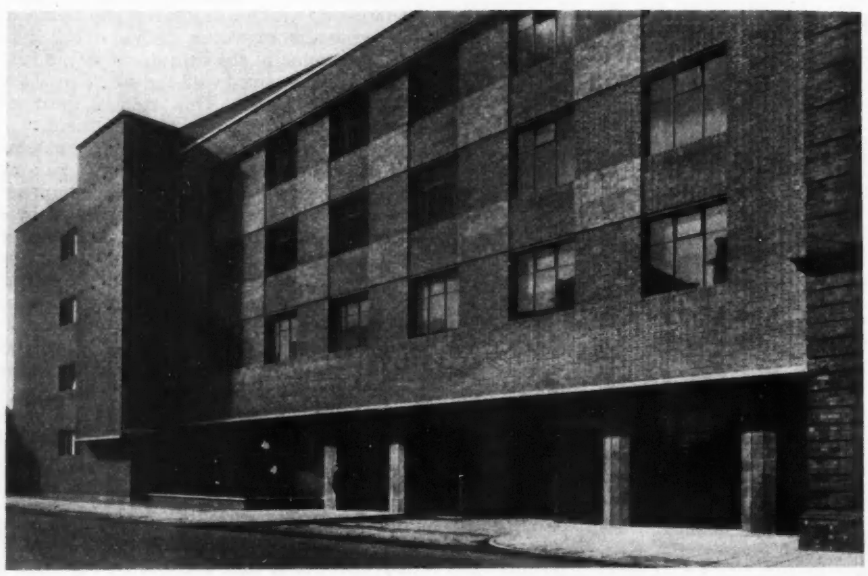
The new building occupies the site of a four-storey mill destroyed during the war, and consists of a basement and four floors in the main block with an office wing acting as a link with the clock tower building. Because of restrictions imposed by the nature of the site the plan adopted was for a central corridor with laboratories on each side, vertical service ducts with stairways, lifts and cloakrooms grouped at each end of the corridor. The laboratories have been based upon the standard module of 25ft 6in by 11ft 9in, each of which is equipped with all services, so that the internal arrangement of the floor areas can be adjusted to suit changes in requirements.

A facade predominantly of brickwork having " Cotswold Grey " coloured facing bricks forms the main road frontage and can be seen in our illustration. The large areas of brickwork assist in insulating the offices from street noises. Steel-framed construction was adopted for the building in conjunction with floors and roof of precast concrete beams, while the laboratory windows are of double glass with spandrels of rough-cast glass having inside insulation of painted wood-wool slabs. Permanent internal walls are of lightweight concrete blocks, while steel partitions are used elsewhere. Bench service pipes are carried in horizontal metal ducts and between these the floor beams are covered with a lightweight screed on which the floor of silver grey thermoplastic tiles is laid. Rubber tiles are laid in the corridors and cork tiles in the offices, and all walls and ceilings are plastered and painted except in the corridors, where ceilings of acoustic tiles conceal air-conditioning ducts. The laboratory benches have a standard framework and movable under-bench units and are of waxed finished oak with 1¼in thick tops of waxed and oiled Burma teak. Gunmetal fittings are provided and also needle valves for the compressed air, gas and vacuum services.

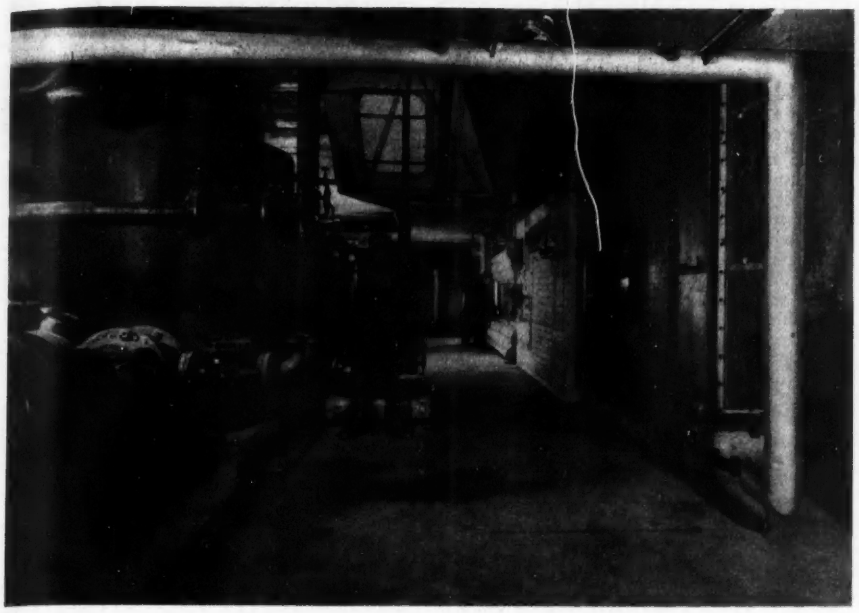
All the services—which include high and low-pressure steam, water for laboratory and domestic purposes, soft, demineralised and hot water, compressed air for general and for instrument use, vacuum, town gas and cooling brine—are distributed by header mains at basement level to vertical risers from which branch pipes lead to island benches through shallow ducts on each floor. The ducts continue to the outside wall and passing underneath the wall benches return alongside a similar duct in the next module. On incoming mains, risers and riser branch mains isolating valves are fitted. Steam at 25 lb and 175 lb per square inch gauge is supplied from the main factory, the high-pressure steam being piped to a small plant room on the first floor, while the low-pressure steam serves the air-conditioning plant air heaters, the heating and hot water calorifiers. The condensate is pumped back to the boiler-house. Water supplies are taken from the city main and lead to a 3600-gallon storage tank, on the roof, from which a service pipe runs down to two Worthington-Simpson centrifugal booster pumps, which maintain the water pressure throughout the building at 30 lb per square inch. All the soft water required is taken from the factory mains, while town's water is treated to provide supplies of demineralised water.

Compressed air for the benches and for general purposes is provided by a Nash compressor rated to deliver 188 cubic feet per minute of free air at 30 lb per square inch, and there are standby arrangements to use air from the main works supply via a mat filter and an alumina filter. A Broom and Wade compressor supplies air at 10 lb per square inch for glass blowing. For the various control instruments there is a special supply of clean air supplied by a rotary water-sealed Nash Hytor compressor, having a capacity of 30 cubic feet of free air per minute at 40 lb per square inch There is an automatic air dryer, having two drying cells, and also an air receiver which ensures a constant pressure in the system. To maintain a vacuum system for filtration and other purposes there is a Nash Hytor vacuum pump having a rated capacity of 100 cubic feet per minute evacuation to a vacuum of 24in of mercury. Town gas is available at all benches and the various branches have lightweight check valves to prevent contamination of the system through breakage. For glass blowing the gas pressure is boosted to 5 lb/10 lb per square inch. A brine supply at about 20 deg. Fah. is obtained from the factory refrigeration plant for use in the air-conditioning systems. Practically all the service plant is mounted in the basement of which we reproduce a general view. As a safeguard for personnel, emergency water showers are fitted in each laboratory near to a fume cupboard, each cupboard having individual exhaust fans with outlets at roof level, which remove 250 cubic feet per minute from double cupboards and 300 cubic feet per minute from single cupboards.

A plenum system, which is divided into three zones on each floor, distributes warmed and filtered air from a central plant of 25,000 cubic feet per minute capacity, and each zone is separately controlled to allow for different sectional heat losses. The main delivery ducts are placed in the corridors above the false ceilings and branch ducts have been formed by encasing the floor beams. A relative humidity of 50 per cent can be maintained in winter conditions by a spray humidifier, and an air heater can raise the air to a temperature of 60 deg. to 65 deg. Fah. In the chemical laboratories the air is supplied on the once-through system, there being no recirculation, but recirculation of air with the addition of a proportion of fresh air is possible in the area where noxious fumes are not present. The fan has a capacity of 15,000 cubic feet per minute and there is a brine coil for cooling the spray water and the plant has dry bulb control and a fixed dew-point. A separate air conditioning plant consisting of a spray air conditioner with steam heater and brine cooler for the water, serves that part of the laboratory which requires air at 68 deg. Fah. and 65 per cent relative humidity. Another plant containing moisture absorption, air cooling and humidification units serves a small variable conditioned laboratory to obtain a temperature of between 50 deg. to 90 deg. Fah., and 25 to 90 per cent relative humidity at any dry bulb temperature in the range given. A non-storage calorifier supplied with steam at 25 lb per square inch gauge provides low-pressure hot water for the wall panels which heat the offices, entrances, &c., the water temperature ranging from 100 deg. to 180 deg. Fah. according to outside conditions. Automatic temperature control is provided for the whole building and the instruments contain fast-response measuring elements, which enable preset conditions to be closely maintained. Fluorescent lighting giving a general intensity of 30 lumens per square foot is installed and other electrical equipment includes an emergency button at each fire hydrant point to stop the air conditioning fans, and a push button at each emergency shower to operate a red light and so summon help. There are two lifts in the building,



Foleshill Road entrance of viscose research laboratory



Service plant in the basement of the viscose research laboratory

one a passenger lift with a capacity of eight persons and a speed of 150ft per minute, and the other a goods lift to take a load of 30 cwt.

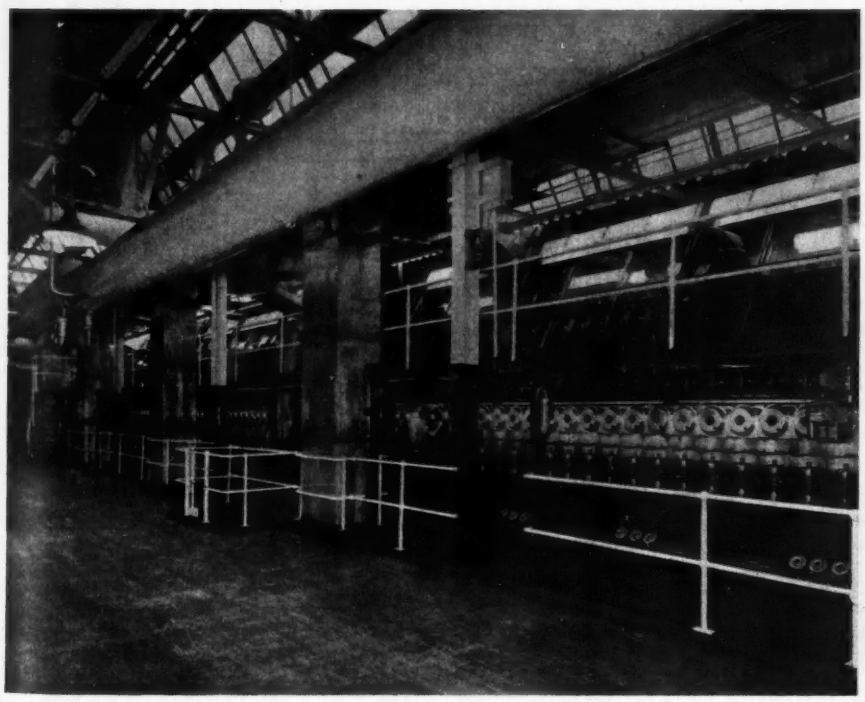
The service plant is in the basement of the new laboratory, where there is also a fully equipped glassworking section for the production of laboratory glasswork ; a tyre cord fatigue testing machine is also installed. Tensile testing of fibres is carried out on the ground floor, and here a machine records the load-extension curve of a single fibre, while another performs the same service for fabrics. Changes in condenser capacity of a yarn evenness tester indicate the presence of slubs and there are single and two fold uptwisters which convert high-tenacity industrial yarns into tyre cord. On the first floor is the pulp laboratory, where the steeping characteristics of pulp sheets are established so that trouble may be avoided in the manufacturing process and where a careful check is made upon the colour which should be pure white if the colour of the yarn is not to be affected. In order to assess the suitability of pulp offered for viscose manufacture there is a small-scale viscose making equipment in which the steeping, pressing, shredding, mercerising, pre-ripening, xanthation, mixing, and testing processes are carried out. In the mercerising stage the pulp is treated with a caustic soda solution for a short period, after which the excess of the solution is pressed out, to produce alkali cellulose. After an ageing period, during which it is oxidised by absorbing oxygen from the atmosphere, the alkali cellulose is treated with carbon disulphide to form cellulose xanthate, which is later dissolved in caustic soda, the resulting viscous solution being known as viscose. Various causes, such as poor quality pulp or faulty manufacturing conditions, can result in an excessive quantity of undissolved material in the viscose. This has adverse effects upon filtration during rayon manufacture, and to avoid such possibilities the viscose laboratory is equipped to measure filterability by means of a simple test. On the same floor is the physics laboratory, and here is an electronic instrument which automatically counts "gels" —the small undissolved jelly-like particles in the viscous solution and which tend to block the filters and the fine holes in the spinnerets. Other equipment records the extension of the yarn under load, measures the friction between the yarn and certain surfaces, and examines fibre structure.

An essential part of viscose manufacture is the reduction in the length of the cellulose molecules and the progressive reduction in molecular chain length is demonstrated in the physical chemistry laboratory on the second floor. The molecular weight distribution of cellulose at various stages is measured in the laboratory, the rate of absorption of oxygen by alkali cellulose being measured and the reaction with carbon disulphide to form cellulose xanthate being observed. An electro-dialysis apparatus removes electrolytes from cellulose research samples ; measurements of optical anisotropy determine the molecular orientation of cellulose ; and the fine structure of the fibres is studied in the laboratory by means of X-ray diffraction patterns and other methods. The work carried out in the organic chemistry laboratory is concerned with yarn lubrication, the adhesion of industrial yarns to rubber and polyvinyl chloride, the treatment of viscose rayon to give it certain properties, and the incorporation of substances to modify the lustre of viscose yarns.

On the third floor is the mass pigmentation laboratory, where the pigments for the mass pigmentation of viscose rayon are evaluated and depth of shade related to particle size. Fabric defects are studied, with a view to tracing faults to their source, in the textile service laboratory, while the analytical laboratory is concerned with the use of ion exchange resins, cathode ray polarography for the estimating of metals in the same solution, optical absorption measurements of iron, copper, manganese, cobalt and sulphide in clear solution, fluorimetry and chromatography.

A visit was paid to the old laboratory, where a "single-end" spinning machine is used to study manufacturing variables and their effect on yarns and where a viscose-making unit carried out the normal batch process on a laboratory scale. The pilot plant building houses a unit for the production of viscose rayon staple, which is chopped up fibre, under experimental conditions, and there is a pilot plant capable of producing experimental viscose rayon staple for commercial evaluation at the rate of 20 tons per week. There is also a continuous spinning machine, seen in our illustration, which produces 15,000 lb per week of experimental high-tenacity industrial yarns, the spinnerets containing as many as 7500 holes. A section of the building is devoted to the study of engineering problems and the development of new and improved mechanisms, components and machines for the manufacture of fibres.

The new building was designed by the various sections of the company's engineering division and the research department, under the direction of the chief engineer, the consulting architect being Sir Howard Robertson, and W. H. Jones and Son, Ltd., being the general contractor.



High tenacity viscose rayon yarn continuous spinning machine

SHIP'S LIFE SAVING APPLIANCES.—This week the Ministry of Transport and Civil Aviation published its *Survey of Life Saving Appliances : Instructions to Surveyors*. The book, copies of which may be obtained from H.M. Stationery Office, price 6s., explains in detail how the Merchant Shipping (Life Saving Appliances) Rules, 1952, are applied. The chapters deal with the rules concerning surveys and survey procedure ; various classes of lifeboats and lifeboat equipment ; lifebuoys and buoyant apparatus ; distress signals, davits and other boat-handling appliances. A series of appendices quote sections of the Merchant Shipping Acts dealing with life-saving appliances, give specifications for life jackets, and include tables giving scantlings for wooden lifeboats.

Gasification of Heavy Fuel Oil by the O.C.C.R. Process

THE heating of furnaces often presents problems relating to flame length and formation, temperature distribution and the nature of the furnace atmosphere. One method of advance towards the solution of these problems, particularly the nature of the furnace atmosphere, relates to the combustion of the resultant products from the gasification of liquid fuel. The combustion of gasified fuel oil has all the advantages obtained from gas firing, such as ease of control of the flame and furnace atmosphere, whilst retaining the inherent superiority of the use of liquid fuel.

A process has been invented and the necessary equipment developed for the gasification of liquid fuel by the "Office Central de Chauffe Rationnelle" (Central Organisation for the Economic Use of Fuel), an association formed in France by a number of industrialists with the support of public bodies. About 100 of these O.C.C.R. gasifier installations are in operation on the Continent and a manufacturing licence covering Great Britain and the Commonwealth countries, has been granted to The Wellman Smith Owen Engineering Corporation, Ltd., Parnell House, Wilton Road, London, S.W.1.

The combustion of gasified fuel oil consists of two steps, namely the gasification of the oil fuel by the application of primary air and the utilisation of the heat of some of the constituents produced in the process; and the combustion of the resulting gas and finely suspended carbon matter with a supply of secondary air at the furnace. The gasifier, as shown by Fig. 1, and diagrammatically, in Fig. 2, consists of a small vertical cylindrical shaft, into the base of which oil and primary air tuyeres are introduced. These are arranged at the periphery in such a manner as to impart a swirling spiral motion to the mixture of oil and gas. The volume of primary air introduced is controlled in relation to the amount of fuel oil supplied to the gasifier. The pressure in the primary air ring main, from which the air tuyeres are supplied, governs the supply of air to the gasifier chamber. Oil is fed to the gasifier from a constant oil level tank situated above the equipment. The pressure in this tank is maintained at that prevailing in the primary air ring main and thus causes oil to be fed to the gasifier through a calibrated orifice in the oil feed pipe in direct ratio to the primary air pressure. By this arrangement, the oil/air ratio is constant for any given primary air pressure and preset orifice diameter. The products of this gasification process leave the top of the gasifier through a refractory-lined tube and are led to one or more burners for combustion with secondary air in a furnace reasonably adjacent to the gasifier. All types of fuel oil, including heavy fuel oils, can be used in the gasifier, provided that the oil, before being supplied to the constant level tank, is heated to a temperature sufficient to give the oil a viscosity of 100 deg. to 150 deg. Redwood No. 1.

Approximately a period of half-an-hour is required to start the gasifier from cold. This length of time is sufficient to heat up the gasifier to the necessary oil cracking temperature, after which it is possible to operate the gasifier and the burners at normal full load. During operation approximately 2 to 4 per cent of the oil gasified, depending upon the nature of the fuel used, is deposited in the form of coke at the base of the gasifier. This deposit takes only a few minutes to remove, after six to eight hours operation, and consequently does not cause any appreciable drop in furnace temperature. For small capacity gasifiers, the primary and secondary air can be supplied from one fan, but for larger size gasifiers, it is preferable to use two fans, one for primary and the other for secondary air, as primary air is supplied at a higher pressure than that of the secondary air. Although Fig. 1 shows the gasifier feeding one burner only, a furnace may be equipped with a number of burners from one gasifier, and such burners would be designed to meet the requirements of the heating process to which the gasifier was being applied.

The products of the gasification of fuel oil depend mainly on the air/oil ratio. The higher this ratio the lower the resultant calorific value of the gas and the higher the temperature of the products leaving the gasifier. With a lower air/oil ratio the calorific value rises and the outlet temperature falls, but due to the lower cracking efficiency, the amount of non-gasified suspended carbon increases. The final results of combustion are not, however, affected to any extent due to the fact that final combustion temperature is a product of the latent and sensible heat of the gas. Including the amount of suspended carbon, which is equivalent to about 30 per cent of the carbon in the oil, the overall thermal efficiency is from 95 to 98 per cent. It will be realised that the oil gasifier is not a gas producer in the normal sense, but an oil cracking plant, and there is a fundamental difference between the oil gasifier process and the conventional gas producer. A gas producer using coal has a cold gas thermal efficiency of from 65 to 70 per cent and a hot gas thermal efficiency at the point of combustion of 75 to 80 per cent. On the other hand, the losses from a heavy oil fuel gasifier amount to only 2 per cent to 3 per cent in respect to radiation and from 1 to 2 per cent in respect to the coke deposited at the base of the gasifier. The composition of the gas and the outlet temperature from the gasifier vary with the air/oil ratio.

The amount of primary air used in the process is approximately one third of the total air required for combustion of the oil or about 60 cubic feet per lb of fuel oil gasified. For a pre-set orifice size the air/oil ratio remains constant and the rate of gasification is therefore entirely dependent on the primary air pressure. For a different air/oil ratio, a different diameter of orifice has to be used, the operation of changing this orifice being affected in a matter of a few minutes.

An approximate analysis of the gas produced is:

	per cent
CO_2	4
CO	16
H_2	14
CH_4	4
N_2	62

The temperature of the gas produced is 1150 deg. to 1250 deg. Cent. and its heating value is as follows:

Net calorific value of the gas	120 B.Th.Us.	per cubic foot at N.T.P.
Sensible heat content	50 B.Th.Us.	per cubic foot.
Heat in suspended carbon	45 B.Th.Us.	per cubic foot.
Total heat value at producer outlet	215 B.Th.Us.	per cubic foot.

The O.C.C.R. fuel oil gasifiers can be supplied in varying capacities, ranging from 6 gallons to 250 gallons per hour. The approximate size of the smallest gasifier is 3ft diameter and the largest capacity gasifier about 6ft diameter. Under normal conditions, the gasifier has a turn-down range to 25 per cent of its full capacity and if specially required it could be arranged to have a turn-down of ten to one by incorporating

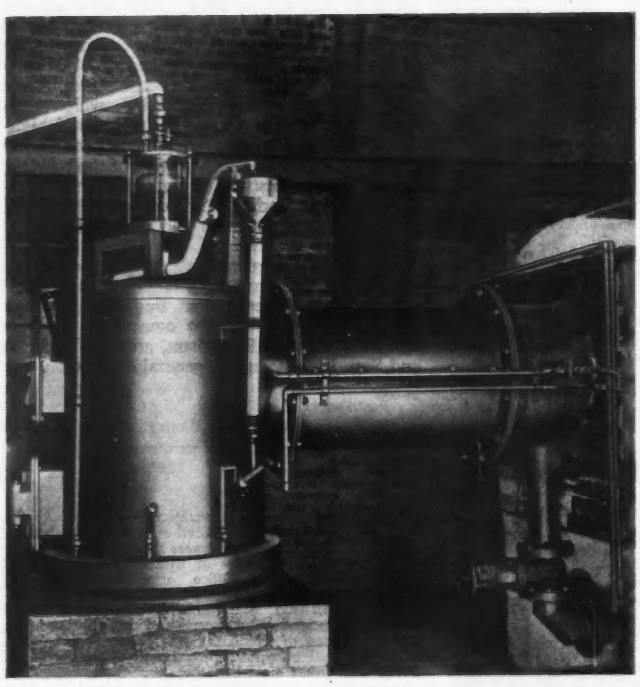


Fig. 1—Liquid fuel gasifier

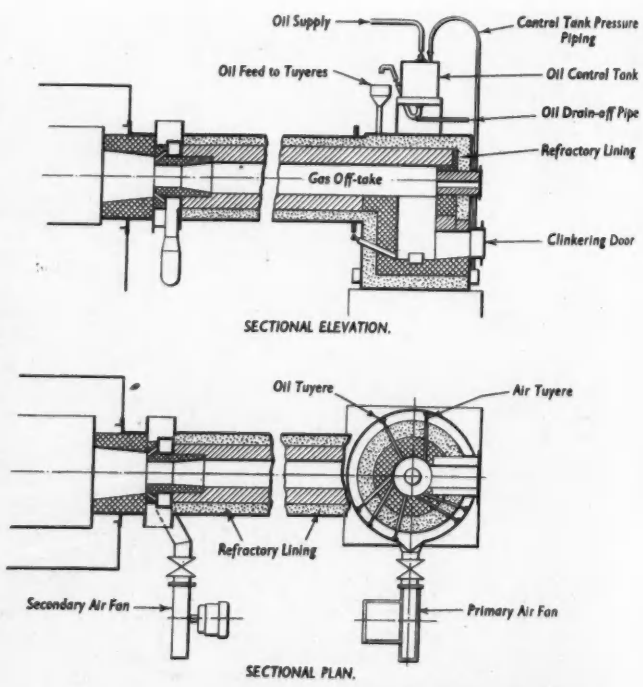


Fig. 2—Diagrammatic arrangement of heavy fuel gasifier

modifications to the tuyeres. One of the chief advantages claimed for the gasifier, as compared with the conventional burner, is its flexibility in being able to create a furnace atmosphere which is slightly reducing, neutral or oxidising. This flexibility is not possible with an orthodox atomising type of oil burner which cannot be operated without 15 to 20 per cent excess air. Furthermore, the normal atomising oil burner, however effective the atomisation of the fuel may be, invariably produces droplets, the deposition of which on the material being heated is considered to be the cause of most of the contamination from sulphur. It is claimed by the inventors of this process that in the case of combustion of gasified fuel oil, the sulphur attack is less than that from an orthodox burner, and tests are being carried out in conjunction with oil companies in this country to confirm this claim.

50 Years' Progress in Life-Saving from Submarines

BY OUR NAVAL CORRESPONDENT

THE sinking of the submarine "Sidon" in Portland Harbour with thirteen officers and men on board after a torpedo explosion has inevitably diverted public attention from a remarkable and encouraging announcement recently issued by the Admiralty on the possibility of escaping from a sunken submarine. Entirely satisfactory ascents, the Admiralty bulletin informs us, have been made by officers and men from a submarine, at a depth of 128ft on the sea bed of Loch Ewe, without the aid of any underwater breathing apparatus. This is indeed an epoch-making event. Every submarine disaster at sea in time of peace gives rise to widespread publicity in the Press and to deep anxiety among the public because of the feeling that there may be men shut up in a steel case at the bottom of the sea waiting to be saved. Suggestions for saving life or improved methods of escape pour into the Admiralty from all parts of the country. Most of them are quite impracticable to implement or would detract from the submarine's capabilities as a war vessel and thus tend to increase casualties in time of war. It is apt to be forgotten that casualties from enemy action are very much more numerous than from other causes. Of the seventy-seven British submarines lost during the second world war all but four were sunk by enemy action. The submarine branch of the Royal Navy has taken the only possible steps to reduce the number of these war casualties by training the crews to the highest standard of efficiency and by ensuring that our submarines have the most efficient military characteristics for their operations. How seldom disasters occur from other causes may be judged from the fact that during the thirty years of peace since 1920 there have only been ten accidents at sea, in spite of the Royal Navy having had an average of fifty submarines in commission during that period.

It was in March, 1904—soon after the little Holland boats were commissioned for service in the Royal Navy—that the first disaster occurred to a British submarine, when "A1" was rammed and sunk when submerged by the S.S. "Berwick Castle," with the loss of all hands. At that time, however, it was not thought even remotely possible that men could actually escape from a sunken submarine. The hazards and difficulties facing men under such conditions were not even investigated, far less understood. The only hope of saving life seemed to lie in the chance of salvaging the vessel or at least in raising her bow or stern out of the water. None the less two important contributions were made during those early years to the safety of personnel. Almost every accident resulted in the learning of material and other lessons which made disasters from a similar cause less likely in the future. After "A1" was sunk, for example, a lower hatch was fitted at the bottom of the conning tower and this modification undoubtedly saved "A9" which was later involved in a similar collision. All submarines have since been fitted with this lower conning hatch and whenever a service passes through the pressure hull, its integrity is always insured by a valve. The second and even more important contribution was the knowledge that the hope of survival was not to have an accident. The submarine branch thus built its reputation for methodical checking and maintenance of all equipment, which, in itself, is likely to save far more lives than any number of interlocks and escape equipments. Later, however, in 1912, it was realised that if there was to be any likely chance of saving life by salvage, or by raising the bow or stern, after a disaster had occurred, the submarine must be fitted with bulkheads. Bulkheads were accordingly fitted in that year in the design of the "E" boats, and it is interesting to note that within the next four years they proved their value in saving life on two occasions. A petty officer managed to close the engine-room bulkhead in "E 41," which had sunk after a collision off Harwich with another submarine and succeeded in coming to the surface from a depth of 30ft. And again in 1916, forty-six officers and men escaped from the forward compartment of "K13," which sank in 38ft of water in the Gareloch while doing her acceptance trials. The accident was observed by another submarine and the whole resources of the Clyde were then applied to salvage, and after two days her bow was raised to the surface.

In the six years following the first world war there were four more accidents, with total loss of life in each case; and, at last, in 1925 serious attention was given to the possibilities of individual escape as an alternative to salvage. The United States had already produced the Momsom Lung with that object and the Germans had made use of the Draegar gear during the war. Finally, in 1930, an important advance was made by the issue to British submarines of the Davis submarine escape apparatus, one for each member of the crew. A year later, the soundness of the new policy was fully justified when eight ratings, using this apparatus, escaped from the fore compartment of the British submarine "Poseidon," which had sunk to a depth of 120ft after collision with a steamer in the China Sea. Several lessons were also learnt from this disaster. There were insufficient sets of the escape apparatus for the number of men who had gathered in the forward compartment and it was clear that more training was required in the use of the apparatus. The men in the "Poseidon" also had great difficulty in opening the hatch. A good deal of air still remained in the compartment after the pressure inside and out had been equalised by flooding and first attempts to open the hatch merely resulted in the release of a large air bubble and the hatch closing down at once. To overcome this difficulty, it was decided to fit a twill trunk to each hatch. The trunk is "stopped up" out of the way when not in use and when let down the small amount of air trapped in it after the compartment is flooded is released through a valve and the hatch opened without difficulty. Each man in turn steps under and inside the trunk and rises to the surface—a procedure which has remained the standard method of escape up to the present day. Above all the "Poseidon" disaster proved the necessity for quicker flooding arrangements. Air contains 79 per cent of nitrogen which, if breathed under pressure, accumulates in the blood and, when released suddenly by a quick ascent to the surface, causes "bends" or diver's paralysis.

As the result of the "Poseidon" accident and the abortive attempt to salvage "M 2"—another submarine disaster which occurred about that time—salvage as a method of rescue was finally abandoned. Henceforth reliance was to be placed on the D.S.E.A. and the twill trunk, with bulkheads strengthened in new construction to withstand a pressure of 200ft. It was also thought advisable to fit a two-man escape chamber in new construction, one at each end of the submarine, the valves and levers for flooding the chamber and opening the hatch to escape being operated by the two men inside it. This was thought to provide a better chance of escape than the twill trunk method. The "Thetis" disaster in 1939, however, proved that the chamber was too complicated and the Nasmith Committee set up after the disaster to review the arrangements for escaping from submarines recommended that it should be abandoned and the twill trunk again fitted in all future submarines. The "Thetis" sank in 150ft of water in Liverpool Bay due to the accidental flooding of the two forward compartments through a torpedo tube while doing her trials. The entire crew and personnel from the builder's yard, numbering 103, escaped immediate drowning and retreated into the after compartment. Instructions for escapes emphasised the need to wait until there were signs that surface ships were on the spot to pick up survivors, but unfortunately the vessel was not located for seventeen hours. Meanwhile, the trapped men made strenuous efforts to bring the submarine to the surface and eventually succeeded in bringing the stern above water. Two men then went into the two-man chamber and succeeded in escaping, using the D.S.E.A., but the stern sank again soon afterwards. Two others subsequently escaped using the D.S.E.A., but there were no more survivors. There is, indeed, little reason to doubt that the hard work done by the crew in their efforts to bring the submarine to the surface had made the air very foul with CO_2 and that all the remaining ninety-nine died from that cause. Evidence of this came from the report of an officer—one of the four who escaped. By the time he had climbed up the steep incline to the stern, he had to rest for a quarter of an hour before gathering sufficient energy to put on his D.S.E.A. set. The CO_2 danger was soon afterwards confirmed by the experiments and research set in train by the Nasmith Committee. CO_2 poisoning, it was discovered, began much sooner under pressure. A concentration of CO_2 that was just permissible at atmospheric pressure was likely to be lethal when the air was compressed ready to escape. It was also ascertained that after ten hours' diving the atmosphere in a submarine was sufficiently foul to be lethal when flooding the compartment at a depth of 150ft. The need to escape quickly was thus made much more evident by these experiments and the committee recommended releasing at once the compressed air left in the submarine while flooding up, to speed up the process and freshen the air.

The "Thetis" disaster in 1939 may be regarded as the end of the second stage in the advancement of life-saving methods from submarines. From 1904 to 1930—salvage; from 1930 to 1939—the Davis escape apparatus. With the second world war came requirements for human torpedoes and midget submarines, which necessitated all kinds of further physiological experiments. These not only confirmed the results of previous research in connection with CO_2, but revealed that the risk of oxygen poisoning from breathing pure oxygen from the D.S.E.A. had been very much underestimated. It was found that oxygen poisoning varies enormously between individuals and may set in after five minutes' breathing oxygen under pressure at 100ft. For the average man it begins after about twenty minutes at this depth. Thus, the wearing of the Davis escape apparatus while flooding up to try and avoid CO_2 poisoning and the "bends" was likely to lead to oxygen poisoning and so push escapers out of the frying pan into the fire. The Admiralty therefore set up yet another committee at the end of the war to inquire into the whole question of submarine escape and rescue. Two broad conclusions were reached by the committee. The main hazard is not the ascent from the sunken submarine, but the period inside the submarine before escaping, especially during flooding up when three-quarters of the casualties occur. Secondly, the committee found that as many men escaped during the war making "free ascents" without any breath-

ing apparatus as with it. The weight of air in the lungs at a pressure corresponding to a depth of 100ft is three times what it is on the surface and all the way up it is necessary to breathe out hard to get rid of the surplus. A deep breath taken before the ascent is quite sufficient to last all the way up to the surface. The main recommendations made by the committee were the installation of a one-man escape chamber at each end of the submarine in all new construction ; that " free ascent " should replace ascent with the D.S.E.A.; and that in existing submarines, which have no room for a one-man escape chamber, mixture breathing sets should be installed at each end of the submarine, to be used, in conjunction with the twill trunks during the flooding up period, instead of the D.S.E.A. It has not, however, been possible to stow 100 per cent of these breathing mixture sets at each end of the submarine and a built-in breathing system has been designed in lieu. This consists of large bottles of a mixture of 40 per cent oxygen and 60 per cent nitrogen built into each end of the vessel with a tube and mouthpiece for each man. The crew breathe from these bottles while flooding up, the time for which has been still further cut down by extra flood valves, and then make a " free ascent " through the hatches fitted with twill trunks.

Thus, both the one-man escape chamber and the built-in breathing system in existing submarines provide the best chance of survival against the two dangers of " bends " and CO_2 without introducing the danger of oxygen poisoning. The one-man chamber is operated from outside by the others in the compartment and the man breathes air at atmospheric pressure until he actually enters the chamber and floods up—an extremely quick process. After thorough tests in a 100ft tank at the Submarine Headquarters last year, it has now been installed in the submarine " Solent," the vessel used in the recent successful ascents in Loch Ewe. It is hoped that it will be satisfactory down to a depth of 300ft, but the chance of survival at that depth, using the chamber and free ascent, are probably no better than even. Subject, however, to the results of trials now in progress, it is intended to fit attachments to the hatch of the chamber to enable a rescue bell—invented by the United States—to be lowered and fixed on to it. With further strengthening of the bulkheads it should then be possible to make escapes down to the full diving depth of the submarine. The disaster to the " Truculent " in January, 1950, not only confirmed the efficacy in shallow water (68ft) of the twill trunk method, with or without the D.S.E.A., but proved the need for immersion suits to keep men alive after coming to the surface. All existing submarines have now been equipped with these suits. The " Affray," though equipped with indicator buoys, was never located and this disaster resulted in the fitting of indicator buoys of an improved pattern with a flashing light. Indicator buoys, equipped with a wireless set with which to summon assistance have also been under trial. All these new devices, particularly the one-man escape chamber and the built-in breathing system, both of which can be used in time of war, should do much to improve the chances of escape. It must be recognised, however, that the price in complexity and weight in the submarine is very large and the inroads into the military characteristics are serious. Moreover, a submarine equipped with these new systems may well be flooded throughout when an accident occurs or be in very deep water when no escape equipment will avail. The best escape policy for the future is still the same as it was fifty years ago—good drill, good maintenance, and attention to sound submarine practice.

WATER CONSERVATION IN NORTHERN RHODESIA.—We have received the report for 1954 of the Water Development and Irrigation Department of Northern Rhodesia. Continued progress in the drilling of wells and in building small earth dams for water supply in rural areas is recorded. The total footage of drilling completed during the year was 19,293ft, giving a yield of nearly 5 m.g.d. The largest dam completed during the year provides 115 acre-feet of storage and involved 30,000 cubic yards of earthwork. Hydrological recordings of the Kafue River at Meshi Teshi and Kafue were made to provide data for the proposed hydro-electric scheme, and a number of other hydrological and geological investigations were in progress.

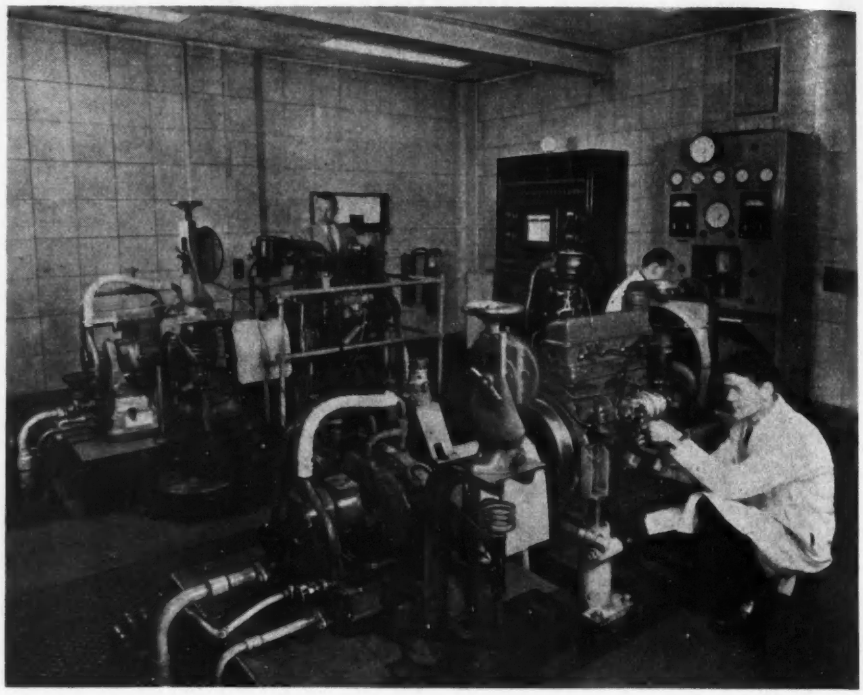
An Automobile Engineering Research Centre

ABOUT three years ago the Ford Motor Company, Ltd., acquired premises in Birmingham for the use of a new engineering research centre. The centre, which is now in operation and nearing completion, was officially opened on July 5th.

The main reason for the building of the new research centre at Birmingham is that most of the important manufacturers of automobile components and many other suppliers of the Ford Company have their own research and design establishments within a 25 miles radius of the city. Further, the proving ground of the Motor Industry Research Association at Lindley, near Nuneaton, some 20 miles away, is within easy reach.

The centre is on a site of just over 65,000 square feet and has a floor area of more than 58,000 square feet ; in view of a further planned extension, another 25,000 square feet of adjoining property have been recently acquired. During 1952 and 1953 the main office block was completed and the centre was made suitable for the experimental machining of small parts and for the testing of commercial vehicles. Last year, further facilities were provided for the testing of motor-cars, tractors and power units ; at the same time, the workshops were enlarged to cope with increased demand for the development and production of new mechanism and structures.

The centre is a complementary part of the company's design engineering division at Dagenham, and its activities are closely co-ordinated with those of the main factory. The work carried



Petrol and diesel engines on test. The recording of engine conditions is automatic

A section of the physical testing laboratory, showing the pulsator fatigue tester

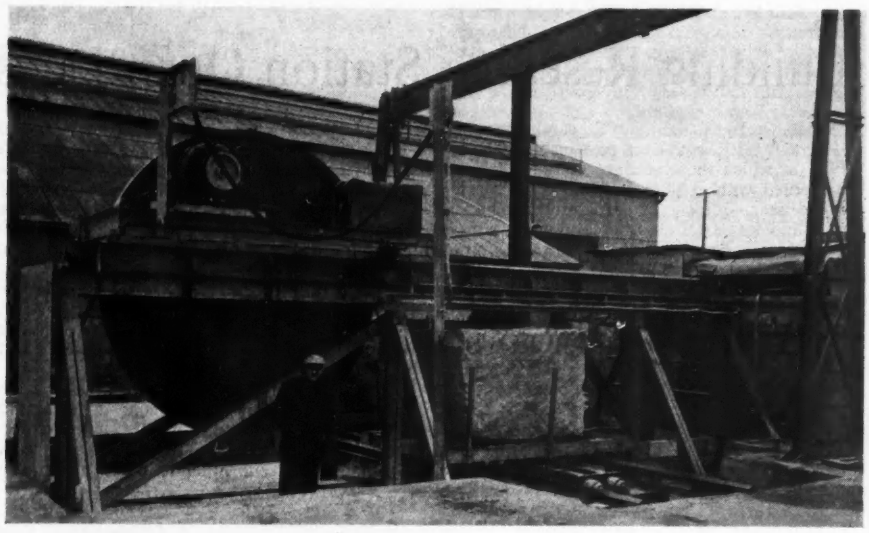
out at Birmingham, however, differs from that done by Dagenham design engineers in that it consists of long-term research. Apart from the design and the preliminary testing of newly developed vehicles, a considerable part of the current research is devoted to the improvement of components, to investigations concerning the use of the latest manufacturing methods and to the testing of new materials. Although the actual long-term research and any development work connected therewith is confidential, the Ford Research Centre collaborates with other research organisations on matters of a more fundamental nature, such as investigations into the general behaviour and suitability of fuels, lubricants, and bearing materials with a view to extending the life and the capacity of vital components.

For this purpose the centre is well equipped with several modern laboratories. In the chemical laboratory such materials as paint, oil, plastics and plating are analysed and tested; it contains an experimental spraying booth and a stoving unit. The metallurgical laboratory has a number of modern testing machines, equipment for microscopic examinations, and a gamma-ray installation which, using radio-active isotopes, is capable of detecting welding, casting or forging defects in metal up to 4in thickness. The physical laboratory deals with the design, installation and maintenance of electronic instruments and with the testing of electrical car equipment. A special section of this laboratory is engaged on full-scale fatigue testing of highly stressed engine and vehicle parts, such as valve operating gear, crankshafts, connecting-rods, &c. An illustration shows the testing of a cast iron crankshaft which is subjected to alternating loads in the axial direction; the stresses in the crankwebs, crankpins and journals are automatically recorded by wire resistance strain gauges.

Considerable space is occupied by the engine test beds, illustrated opposite, some of which are fitted with fully automatic control panels. An electronically controlled dynamometer for the testing of tractor engines is due to be installed shortly. To ensure that future power units and vehicle components will be better suited to withstand the rigorous conditions experienced in Arctic regions, cold rooms, as shown below, have been built to simulate these conditions.

The departments engaged on design are housed in well-lighted spacious offices. In the car drawing-office the work of other sections is correlated into the design and detailing of prototypes of experimental passenger vehicles. The tractor and implement research section deals with general research on agricultural tractors. The power unit section is engaged on the design and the development of experimental engines.

The workshops used for producing new components and modifying existing ones include a well-equipped machine shop, capable of making most of the mechanical parts (with the exception of spiral bevel gearing, camshafts and profile-ground pistons), which are normally made at Dagenham. Further facilities are provided by a woodworking shop for making mock-ups, a sheet metal shop and an assembly shop for prototype building.



Gantry stone sawing machine with a 139½in diameter blade, fitted with two tables, each designed to carry blocks of stone weighing up to 25 tons

Large Stone Sawing Machine

A STONE sawing machine of particularly large capacity, designed and built at the Carnoustie works of the Anderson-Grice Company, Ltd., was recently installed in the Portland quarries of the South Western Stone Company, Ltd. It is intended for sawing blocks of stone, as quarried, into thick slabs suitable for reduction into blocks for building purposes on standard stone working machines. The machine is fitted with a circular steel blade of 139½in diameter and is capable of sawing block stone up to 5ft. thick and 12ft. long.

As can be seen in the photograph reproduced on this page, the saw carriage is mounted on an elevated gantry which is 40ft long, and all the movements are controlled by an operator seated in a cabin at one end of the machine. This carriage runs along rails bolted to the top longitudinal members of the gantry to traverse the saw across the block of stone on a table below. The carriage is built of steel sections and carries a 45 h.p. motor, which drives the saw spindle through a duplex chain and sprockets. The saw spindle is supported on ball and roller bearings in brackets on the underside of the carriage, and with a spindle speed of 287 r.p.m. the 139½in diameter blade has a peripheral speed of 10,500ft per minute. An electro-magnetic brake is fitted to the saw motor.

With a saw of this size and speed a steady positive feed rate is of particular importance, and the carriage is drawn along the gantry by a long-feed screw engaging in a nut attached to the underside of the carriage. This feed spindle is driven through gearing by a 10 h.p. motor at one end of the gantry. The drive is transmitted through a variable-speed unit and worm, bevel, and spur reduction gears giving a range of feed rates from 3·25in to 16·25in per minute. To save time in setting a rapid carriage traverse movement of 20ft per minute is available in each direction of travel.

The carriage feed drive is designed to adjust the rate of feed automatically in accordance with the texture of the stone. This arrangement ensures that the motor driving the saw blade always runs at or near full load. It is effected by the insertion of a variable resistance in the rotor circuit of the slip ring carriage feed motor, so that this motor speeds up or slows down in accordance with the load.

The gantry bridges transverse ways on which two cast iron work tables are mounted, two tables being fitted to the machine so that one can be loaded whilst the block of stone on the other is being sawn. Each of these tables is 10ft wide by 6ft long and is designed to carry a block of stone weighing up to 25 tons. The tables are traversed by a 7½ h.p. motor driving individual feed screws through spur reduction and bevel gears. A clutch fitted on the drive is used to select the table to be traversed, and this control unit is designed to prevent simultaneous operation of the tables. Through a drum controller in the cabin the operator of the machine can position either table within very close limits, the table setting being carried out from the cabin with reference to a dial indicator which is graduated to show the amount of travel in feet, inches and sixteenths of an inch. With these controls it is claimed that repeated slices can be cut off a 25-ton block of stone to an accuracy of ⅛in. A means of compensating adjustment is provided to make allowance for saw draft formed by the blade.

The saw used on this machine is believed to be the largest circular steel blade ever manufactured, and it was specially rolled at the works of Colvilles Ltd. The flattening of the blade before it was machined, and its tensioning before being placed in service, was carried out by a team of sawsmiths from Spear and Jackson, Ltd. Round the peripheral edge of the blade 300 steel teeth are inserted, each working tooth being fitted with a diamond weighing seven-eighths of a carat. A few special teeth, which serve to impart a smooth finish to the sawn face of the stone, carry a number of small diamonds.

An engine on test in a cold room in which polar conditions are reproduced

Building Research Station Open Days

THIS week, the Building Research Station of the D.S.I.R. held open days on July 18th and 19th, at which those sections of the laboratory concerned with civil engineering research were to be seen—principally structural engineering tests and investigations, but also work on soil mechanics, concrete technology, the development of measuring instruments, and so on.

This aspect of the Station's work was selected for exhibition this year because it is considered that recent improvements in structural design are not being applied sufficiently in practice. The exhibits to be seen tended to emphasise " load factor " methods of design, and economies which may be achieved by taking into account such factors as rigid joints in steel-framed buildings and the load-bearing capabilities of the concrete encasement of steel frames. Some of the work to be seen at the open days has been selected for brief description in the paragraphs below.

Steel-Framed Buildings.—Tests on beam and slab systems, concrete-encased steel members and of an infilled frame subjected to a racking test (shown in the illustration) were to be seen, and there were display panels illustrating field and laboratory tests on multi-storey steel frames.

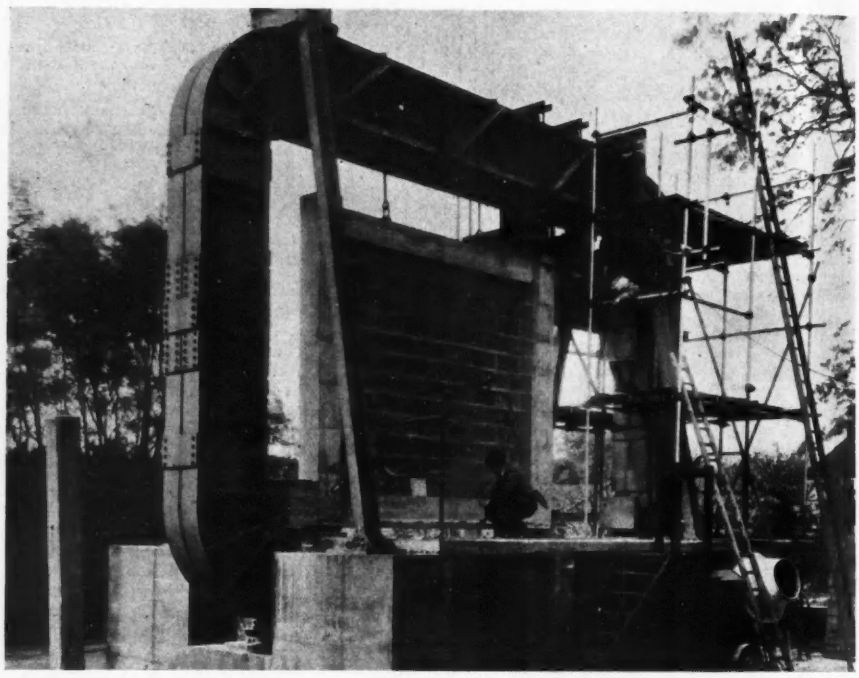
The development of new methods of design, based on a suitable load factor against collapse, has not yet reached the stage where general design rules for multi-storey frames can be formulated so as to be readily applicable in the drawing-office. Attention has therefore been given at the Station to the possibility of improving the design method based essentially on elastic behaviour of the structure, in the hope that the economies inherently possible by the provision of, and allowance for, rigid joints might be realised now.

The main problem in designing large rigid frames is to find a method which is sufficiently accurate whilst avoiding heavy design costs. A reasonable degree of accuracy is essential; whereas considerable economies are possible with a fairly accurate analysis, much of the saving is forfeited if over-simplified conservative methods are used.

In designing a rigid frame the choice of every member is theoretically dependent on the sections chosen for all the other members. If every variable were taken into account the design would become unduly complicated. The chief difficulty in producing a design method is thus to determine which variables are important and which can be neglected, and to reduce the important variables to a sufficiently small number. In order to do this, a rapid method of analysing rigid frames has been developed at the Station by means of which the separate effects of many variables have been studied for a large number of frames.* From this work it appears that many opposing tendencies are to be found in rigid frames, whereby certain effects are counterbalanced by others, leaving only a few principal characteristics which need be studied by the designer. These characteristics can be embodied into idealised substitute frames which, for design purposes, can be deemed to take the place of the real frames. Accurate analysis has been made of these substitute frames and the bending moments so obtained have been set out in design charts. All that the designer has to do is to work out certain ratios of stiffness for the various members and enter the charts with these ratios to find the bending moments. The method is in fact a development of the work of the Steel Structures Research Committee, using, however, the results of analysis of a more extensive series of substitute frames. How a designer may make use of this simplified system is described in the Station's note No. A47, " Rapid Design of Multi-Storey Rigid-Jointed Steel Frames."

Although design on the basis of collapse is not yet practicable for multi-storey frames, it is possible and reasonable to make some allowance for the redistribution of moments that occurs at high loads as a result of plasticity, in a way similar to that adopted for many years in reinforced concrete design. The design charts prepared by the Station do in fact make some such allowance by permitting, with some qualifications, an increase of 15 per cent in the permissible stresses in beams, provided that the sum of the stresses at the support and at the critical span section does not exceed twice the normal permissible stress. With the methods suggested savings of some 10 to 20 per cent of steel may be obtained by designing building frameworks with rigid joints.

Current methods of design already make some allowance for the stiffening of the framework by the floors, but, clearly, if more were known about the degree of stiffening imparted by these floors and other infillings, and by the encasements to the steel members themselves, much more realistic allowances could be made and still greater economies in steelwork would result. It is for this reason that so much attention is being also paid at the Station to the subject of composite action.



Concrete-encased steel frame subjected to a racking load. The panel infilling considerably increases the stiffness and strength of the frame

Reinforced Concrete.—Research at present in hand concerns the strengths of reinforced concrete walls, shell roofs, and slender beams, and the value of compression reinforcement in beams.

The tests on walls were initiated to provide basic information for the guidance of designers of multi-storey buildings and were made on full-size walls and model walls to determine the effects on wall strengths, deformation under load and mode of failure, of varying the wall dimensions and reinforcement in cases of axial and eccentric compression. The influence of window and door openings has also been examined. One interesting feature of the results is that, for a particular height and thickness, the ultimate load that can be supported per foot length of wall increases with the length of wall. Allowance for this is introduced in the draft revision of the Code of Practice CP 114, which was recently issued by the British Standards Institution for comment.

Considerable help was given by the Station during the preparation of the revised draft for CP 114 and the Station supports the new recommendations for load factor methods of design included in this draft. In order to give immediate help on points of detail in the Code, tests are being made to investigate the strength of slender beams, and already it is clear that the requirements of previous codes were unduly conservative ; beams are also being tested with varying amounts of compression reinforcement to check the proposals for the design of such beams included in the Code on a load factor basis.

The load factor method of design, in its most general form, must allow for the variability of all the factors which affect the balance between the strength of the structure and the loads it supports. One important feature of this is the quality of the concrete used in constructional work and the degree of its control. This is a subject which has been given considerable attention by the Station over a period of many years and an attempt has been made to introduce in the draft revision of the Code a more rational approach to concrete mix design than that of resorting to " nominal mixes " as in the past. It is hoped that the new provisions in the Code for designing concrete to give the strength and workability required will be widely used.

Soil Mechanics.—One of the recent researches undertaken by the Station's soil mechanics section concerns the stability of sea defence embankments. A model showed the arrangement of a full-scale test which is to be carried out to determine the precise mode of failure of a bank which is overtopped. A length of bank will be enclosed by a steel-sheet-piled cofferdam and water impounded in the dam, thus maintaining the desired seaward and landward water levels throughout the test.

The Station points out that the issue of the new civil engineering code of practice on " Foundations " (No. 4) represents a step forward in the application of the work on soil testing and site exploration to practice.

* Wood, R. H.: " An Economical Design of Rigid Steel Frames for Multi-Storey Buildings," National Building Studies Research Paper No. 10, H.M.S.O., 1951.

HIGHWAY ENGINEERING SUMMER SCHOOL.—The civil engineering department of the University of Birmingham is proposing to hold a two weeks' School in Highway Engineering between September 12 and 24, 1955. The lectures dealing with traffic and safety and the construction of roads, will be delivered by a team of lecturers from various organisations. Some foreign engineers with experience in the design and construction of motor roads have also been asked to lecture. The direct aim of this school will be to acquaint civil engineers practising in the Midlands with the latest methods of road design.

H.M.S. "Grey Goose"

Two experimental R.M.60 gas turbines of advanced design have been installed in the gunboat H.M.S. "Grey Goose," in place of the original steam turbine machinery, and the ship, now acting as a floating test bed, is attached to H.M.S. "Hornet." An outline description is given of the gas turbine cycle and of the gas turbine installation, which has a total power of 10,800 b.h.p., compared with the 8000 s.h.p. of the steam machinery.

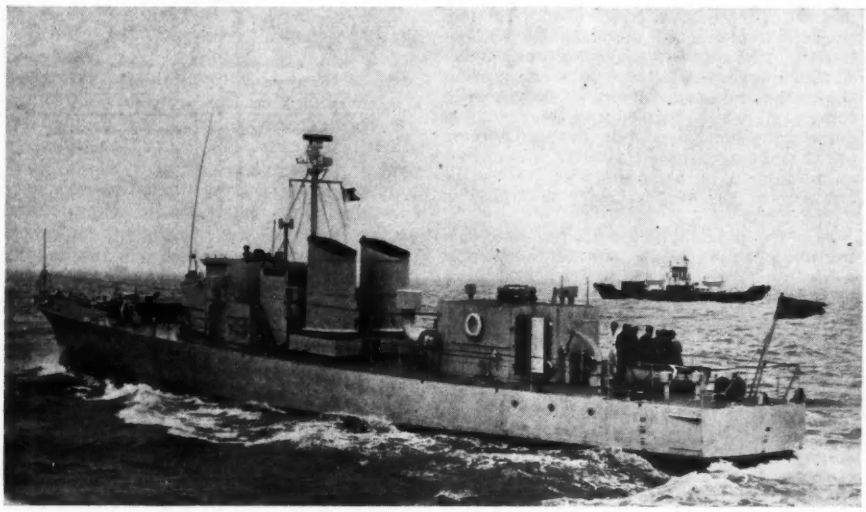
RECENTLY, by the courtesy of the Admiralty, we were able to make a short sea voyage in H.M.S. "Grey Goose," seen on trials in our illustration, which is now attached to the trials squadron at the Gosport coastal forces base, H.M.S. "Hornet," and was commissioned on June 22nd. The appearance of the ship at the base marks the culmination of plans formulated after the end of the second world war for the development of a gas turbine for naval use. The development contract was placed with Rolls-Royce, Ltd., and to meet naval requirements of maximum economy, especially at medium powers, and of a wide power range, a compound cycle was chosen. This includes a low-pressure axial-flow compressor and a high-pressure two-stage centrifugal compressor with intercooling between each compression stage. Other factors, such as the engine room space available, influenced the general layout of the engine and imposed certain restrictions upon the design, while racking movements and longitudinal deflections of the hull, due to hogging and sagging stresses, resulted in the engine being in two parts and connected to other sub-assemblies by flexible bellows jointed ducting.

The low-pressure unit consists of a discharge casing, an eleven-stage low-pressure axial compressor driven by a two-stage low-pressure turbine, all being supported by a three-point trunnion system. This system also supports the high-pressure unit consisting of a two-stage power turbine and a single-stage high-pressure turbine driving a two-stage centrifugal high-pressure compressor, and a high-speed reduction gearbox. Air enters the low-pressure compressor and passes through sea water-cooled low-pressure intercoolers, arranged to port and starboard, on its way to the first stage of the high-pressure compressor, after which it is cooled in the sea water high-pressure intercooler. The air pressure is raised in the second stage of the compressor and is admitted to the port and starboard combustion chambers after passing through the exhaust heat exchanger. Expansion of gases takes place across the single-stage high-pressure turbine and then the two-stage power turbine, which drives the propeller through reduction gearing, and the gases are expanded further at the two-stage low-pressure turbine before passing into the funnel.

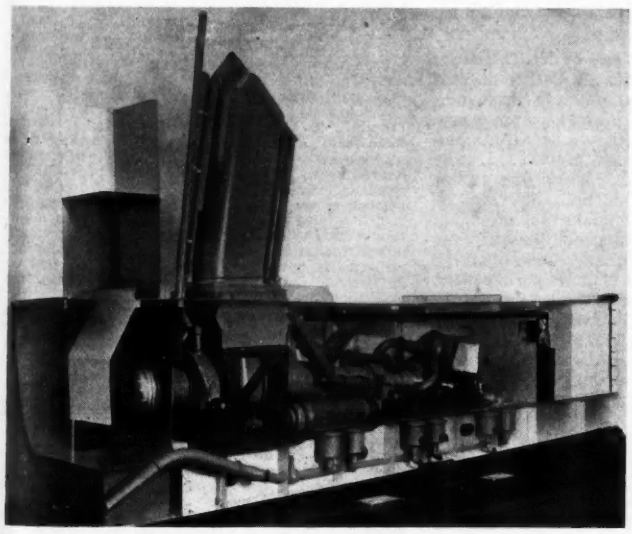
Ball and roller bearings support the hollow shaft carrying the ferritic steel overhung turbine discs, with their K.E. 965 blading, of the low-pressure turbine, which is coupled through a floating coupling to the low-pressure compressor. This has an aluminium alloy casing, aluminium-bronze blades and a stainless steel rotor and discs and is mounted as a cantilever with its intake arranged to pass through the engine room forward bulkhead into the air settling space. Nozzles spray distilled water radially into the compressor intake to pass through the compressor blades and wash away any salt deposits. This is done from time to time when indicated as necessary by a performance check on compressor efficiency. Only 2 per cent in efficiency at design speed has been sacrificed to achieve a wide range of efficiency over an extensive speed range. Nimonic 90 blading is used for the h.p. turbine, which has an overall efficiency of 85 per cent, and Nimonic 80 blading for the power turbine, which operates over a two-to-one speed variation and drives a shaft which passes through the h.p. turbine and compressor. The compressor impellers are of stainless steel, and based on shaft horsepower the compressor has an efficiency of 84·5 per cent.

Power is transmitted by a pinion of the high-speed gearbox, which meshes with three driven gears and then by three flexible layshafts to the low-speed gearbox, where pinions drive a central bull gear. A torsion coupling transmits the drive to the propeller shafting.

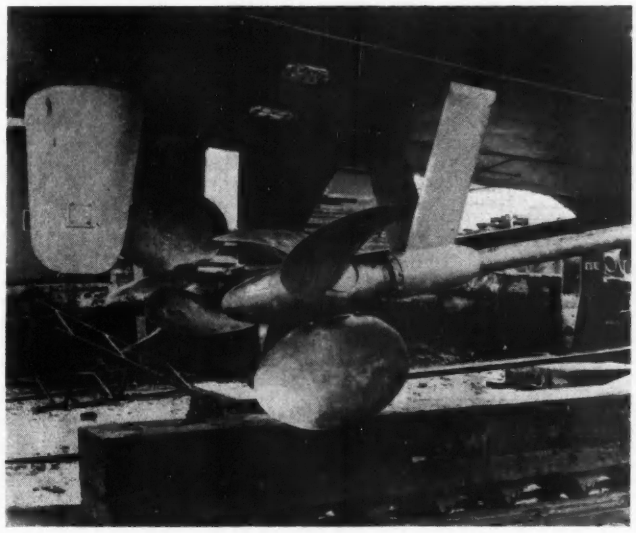
There are two aircraft pattern combustion chambers, having stainless steel air casings and a flame tube, &c., of Nimonic 75, complete with torch igniter and high-tension sparking plug. Normal fuel supply is by low-pressure pump to two high-pressure injection pumps, while for starting a vane pump delivers oil to the torch igniters. A throttle handwheel and levers operating the starting throttle, propeller pitch, heat exchanger by-pass and fuel shut-off cock control the engine, and starting is by a 40 h.p. electric motor driving the high-pressure turbine and compressor through gearing and which cuts out at 5000 r.p.m. A fuller and more detailed technical description of the R.M.60 engine, together with line drawings, diagrams and test bed results



H.M.S. "Grey Goose" on trial



Model of arrangement of R.M.60 gas turbine in "Grey Goose"



Variable pitch propellers in H.M.S. "Grey Goose"

appeared in THE ENGINEER of November 13, 1953.

In 1951 the prototype engine began running tests. Two engines were built and ran for 2000 hours on the test bed at the builders' works and then following 1100 hours of shore development trials, were installed in H.M.S. "Grey Goose" for sea and evaluation trials. The "Grey Goose," it will be remembered, was built in 1941 by J. Samuel White and Co., Ltd., and has a length overall of 146ft by 20ft beam, and a displacement of 205 tons. Two sets of single reduction geared steam turbines taking steam from a single boiler and developing a total of 8000 s.h.p. at 14 lb per shaft horsepower formed the original power unit. The R.M.60 gas turbines now installed each develop about 5400 s.h.p. at 5 lb per horsepower, and so provide 35 per cent more power for a 50 per cent reduction in weight, while the space occupied is about 25 per cent less than that required for the original steam turbine machinery.

The task of installing the experimental gas turbines has been the responsibility of Vosper, Ltd., and has involved a considerable amount of structural alteration apart from the actual removal of the original power plant. The hull has been reconditioned, accommodation reconstructed, new engine seatings built and other detailed alterations effected, such as twin funnels, air intakes and control house, to complete the conversion, which entailed the solution of a number of problems set up by the narrow beam of 25ft and the restricted headroom. We include an illustration of a model, which shows the arrangement of the R.M.60 gas turbine in "Grey Goose."

Since the gas turbines are not reversible controllable pitch propellers have been adopted as a means of manœuvring. They have been designed and made by Rotol, Ltd., and can be seen in another illustration. Reversing of the propeller is achieved by coarsening the pitch through the "feather" position and then into reverse, a method which allows a high disc-area ratio, reduces cavitation losses and keeps the pitch-changing loads fairly low. Engine fuel controls and propeller pitch are linked to give correct pitch for the appropriate throttle opening, the arrangement being such that change of pitch can only take place up to about 600 s.h.p., while above this power the pitch is automatically locked. This power is adequate for manœuvring purposes, and above this power a 40 deg. fixed pitch is suitable for operational requirements. However, with reverse pitch it is possible to permit the power to exceed 600 s.h.p. Each propeller has a hub of 14½in diameter with blades of 4ft 6in diameter and a pitch range from 40½ deg. to 90 deg. ahead, and through a zero thrust angle of 90 deg. to 134 deg. astern. Should the hydraulically operated pitch-changing mechanism fail an automatic blade pitch-locking device operates. The operating piston can be jacked into a mean position and mechanically locked, while an electrically driven independent oil pump is available for pitch changing when normal power is not available. The propeller pitch changes from ahead to astern at 10 deg. per second.

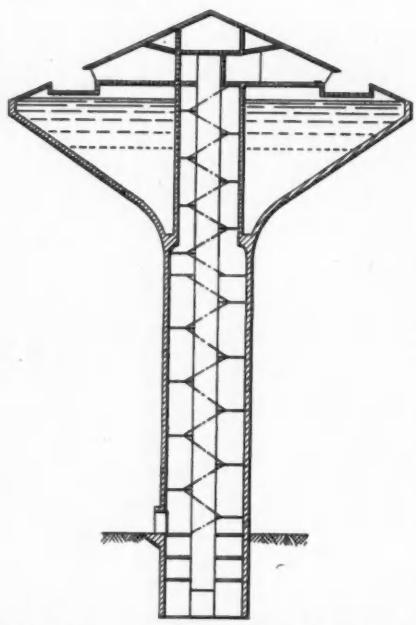
Evaluation and other trials programmes are at present in hand, but the turbine has not as yet been worked up to full power. The sea water scoops which supply the intercoolers have been modified to get a better head and adjustments made to the outlet scoops, and an ejector pump installed. It is possible to increase power very rapidly and tests have indicated that 250 s.h.p. can be achieved in two seconds and built up to 600 s.h.p. in a further thirty-one seconds and then raised to 3500 s.h.p. in eighteen seconds. All the controls are mounted in a house, located aft, which is fully insulated against noise; however, since no one is required to be on watch in the engine-room no sound insulation has been fitted in that space. For occasional inspection of the engines personnel are supplied with ear muffs since the sound level is more than 100 decibels. To date, the trials have confirmed the fuel consumption figures arrived at from recorded performance data, namely, 0·95 lb per brake horsepower per hour at 500 b.h.p., 0·74 lb at 1000 b.h.p., 0·61 lb at half-power, and 0·66 lb at full power.

International Water Supply Congress and Exhibition

THE International Water Supply Association has been holding its third international congress during the course of this week at the Royal Horticultural Society's premises at Westminster. This is the third international congress organised by the association; the first was held in Amsterdam in 1949, and the second was held in Paris in 1952. This year there is also an exhibition, which is also at the Royal Horticultural Society's Hall, at which manufacturers serving the water supply industry are exhibiting their products.

The papers presented at the congress not only expound the various authors' points of view, but also include information gathered, in answer to questionnaires, from delegates in the various member countries, the authors having acted a rapporteurs. Brief summaries of the papers are given hereunder.

Protection of Pipelines Against Water Hammer (in French), by Ch. Dubin, chief engineer of the Paris water company. This report deals chiefly



Design for a prestressed concrete water tower at Orebro, Sweden. It is 50m in height with a capacity of 8500 cubic metres. There will be a restaurant on the roof

with the protection of a distribution network against water hammer, and is based on numerous national reports. The subject is dealt with in considerable detail, and there is a bibliography, but it is pointed out that the problem is more often approached from the point of view of the turbine user than the pump user.

Pumping Station Equipment, by H. R. Lupton (consulting engineer), treats the six headings of (*a*) fundamentals, (*b*) design, (*c*) duty and layout, (*d*) ancillary plant, (*e*) policy, and (*f*) appearance with the aim of dealing with new departures and trends rather than established practice. During the course of this thorough paper, the author points out that he has long been impressed by the apparent neglect of fundamental principles in many theories about impeller pumps; the paper includes a set of diagrams based upon the laws of motion, of the flow within simple impellers.

Design and Construction of Water Towers, by H. Bjorkland (Sweden). This paper investigates, first, the basic requirements of service reservoirs, factors affecting reservoir capacity and its relationship to daily consumption, the siting of service reservoirs, their connections to the distribution network, and the equipment used for measuring and controlling flow and levels in them. The second part of the paper outlines various structural methods employed in building service reservoirs and water towers, and there is a supplement of photographs illustrating recent construction. Of these, the project for a prestressed water tower in Sweden, illustrated in the cross-sectional diagram herewith, which is reproduced from the paper, is the most impressive. There are, however, a number of other examples of water towers and service reservoirs which combine structural efficiency with a pleasing appearance. Of those in Great Britain, the illustrations of the Pollock "C" and "D" water towers in Glasgow are noteworthy, as is the barrel-vault roof construction of the Hambledon Low service reservoir.

Aeration and Deferrisation, by Dr. L. H. Louwe Kooijmans (Netherlands). It is pointed out that the combination of aeration and iron and manganese removal is logical, the effect of "deferrisation" depending to a great extent on a good aeration. New developments are again emphasised.

Factors of Safety in Supply and Delivery Systems, by A. Vibert (in French). The following factors are investigated in this paper:—Estimation of demand; sources of supply; conveyance from source works; reservoirs, and distribution mains.

Use of Electronic Apparatus in Waterworks Practices, with Special Reference to Waste Detection, by R.E.A.X. Despiegelaere(Belgium). This paper records (in French) the stage reached in the use of electronic apparatus in waterworks undertakings. The principal use of such apparatus appears to be in Great Britain, the United States, France and Sweden.

Comparison between Slow Sand and Rapid Filters, by Dr. A. Van de Vloed. The author points out that filtration by sand is a somewhat paradoxical process, the fundamentals of which are by no means fully understood. Even now, sand filtration is regarded as an art rather than a science. One school of thought, he notes, asserts that it is difficult to understand why slow sand filters should be used, except where already installed, as the rapid gravity method is more economical. Nevertheless, the Metropolitan Water Board considers their use, as secondary filters, is the only proved method of treating impounded Thames water. Dr. Van de Vloed gives explanations of the filtering action in terms of adsorption, a phenomenon he considers in need of investigation. A comparison between slow sand and rapid gravity filters used alone is rather difficult, he notes, because these apparatuses are constructed to treat different kinds of water. New solutions are being sought to this problem, one of the most interesting of which, he contends, is the coagulator or "accelator"; the water to be clarified is made to pass through a floating mass, or thick layer of colloidal floc which acts as a filter medium. The unwanted matter is retained by this medium and the clarified effluent flows up and out at the top of the tank.

Training of Waterworks Operators, by H. R. Davenport (Bolton Corporation Waterworks), and *Methods of Charging for Water*, by E. Sherman Chase (U.S.A.). These two papers review contemporary practice in these two subjects, as revealed by answers to the association's questionnaires.

POST-GRADUATE COURSE IN PUBLIC HEALTH ENGINEERING.—The fifth post-graduate course in public health engineering given by the Imperial College of Science and Technology and the London School of Hygiene and Tropical Medicine was held from October, 1954, to June, 1955. In this fifth course, the average age of the students was about twenty-eight and they had had up to fourteen years' practical engineering experience. The syllabus of the course remains basically the same as in previous years. Several outside lecturers were again invited to give lectures on special topics, including the conservation of organic wastes, limnology, and housing in the tropics. Two students who took the course in earlier years have been working on research into two fundamental processes in water and sewage treatment, sedimentation and filtration. These are long-term projects which will be followed up by other research students in later years. An investigation has also been started into thermal effects and water quality in a newly filled impounding reservoir. As a complementary arrangement to that by which the public health engineering students spend part of their time at the London School of Hygiene, more emphasis has been laid during the last two years on the training of doctors taking their diploma in public health in the problems of environmental control by engineering and other means. During the past session, a group of these doctors, augmented by other public health workers, made a special study of the new towns. They also studied, through lectures, discussions and visits, a variety of topics, including atmospheric pollution, housing, road safety and modern methods of refuse disposal. Special lectures on public health engineering were again given to the whole class.

Some Farnborough Memories

By H. E. WIMPERIS*

THE completion this month of Farnborough's brilliant record of service in aeronautical progress during the last fifty years will raise many memories in many minds. There must be few left, indeed, whose experience can range over the whole of that period, but there will be some at least with first-hand knowledge of certain brilliant instances of scientific endeavour which, in the mass, formed part of the record that has made Farnborough famous throughout the whole aeronautical world. Brief impressions are given here of some of these endeavours of which I had personal knowledge, dating from the early days of World War I and extending to those inter-war years during most of which I had the happy privilege of directing (from the Air Ministry) its scientific programme of research.

It is easy nowadays to forget how uncertain in its ways and habits was the early form of airplane, the least certain element of all being the engine. To get the engine to function properly and to continue doing so was the very first essential: next came the skill required for aerodynamic control once the craft was in the air. The solution of the first meant arduous work which could not be hurried. The second needed not only youthful enthusiasm, but often considerable courage. A great step forward was made with the production of the "BE2C" airplane —the first airplane to have a measure of inherent stability. I remember vividly my first flight on one of those machines—at the modest altitude of some 1300ft—with the gallant Busk as my pilot. That was in the year 1914, but unfortunately within the next week (on November 5th) that very airplane, with the same pilot, caught fire in the air and the pilot lost his life, and Farnborough one of its ablest men.

In those days the "spin" was looked upon as one of the very risky manœuvres which badly needed study, but the solution of this problem was both difficult and dangerous. Fortunately, the advent of the first world war had attracted to Farnborough some of the keenest young scientific men of the day, not a few from either Oxford or Cambridge. The theoretical studies on which some of them at once became engaged did before long enable predictions to be made as to a method of piloting control which should enable the aircraft to be got out of the spin and into normal control; but this sounded to Farnborough's test pilots as a somewhat highbrow proposal and one not at all tempting. To this not unnatural reluctance there could be but one reply and that was for someone on the theoretical side to learn to fly and have the courage to try out the proposed new remedy. How many shared in this brave effort the official records may perhaps show, but my recollection is that the leading spirit was Professor Lindemann (now Lord Cherwell), who succeeded in demonstrating that "spinning" need no longer be looked on as a dangerous item to include in normal aerobatics. This first full-scale experimental and mathematical investigation into spinning was reported to the Research Committee in March, 1918, under the names of Lindemann, Glauert and Harris. To the previously unconverted this joint effort showed how science could really help in the future development of the practical art of flying and it led to a full appreciation of science as a necessary tool in the carrying out of Farnborough's tasks. That such missionary effort was required may surprise the younger readers of to-day, when events such as the quite dramatic success of Farnborough's recent investigation into the cause of the "Comet" crashes has been accepted as an almost routine affair! In the passing years it was pleasant to see how the very different gifts of test piloting and scientific ability could be combined in the same individual. One needs only to cite the instance of a fine test pilot (Roderic Hill) who, after service in command of the air defence of this country, became Rector of the Imperial College of Science.

Fruitful as had been this first attack on the phenomenon of spinning, it was still necessary that the subject should continue to be studied, in order to obtain a fuller understanding of the effect on the spin of the various possible uses of elevator and ailerons. With this in view, the Aerodynamics Department devised an ingenious and novel form of wind tunnel, in which the air stream was caused to travel vertically upwards instead of horizontally, and the model instead of being held in a fixed position was allowed to fly freely by itself. This first spinning tunnel had a diameter of but 2ft with the speed of the upward stream of air adjustable until it equalled the vertical rate of fall of the freely spinning model. In this way an observer was able to watch, through a window in the tunnel wall, the model spinning continuously at a seemingly constant height, and the effect could be noted on the ensuing motion of any alteration in the setting of the controls—such alterations being made either by preset clockwork carried in the model or by the use of a radio signal from outside. The models used had to be made not only geometrically similar, but dynamically similar, to the full-sized machine—that is, the dimensions, the mass and the moments of inertia needed to be true to scale. For this it was found best to build the models out of balsa wood and to ballast them with lead in appropriate places. This tunnel proved to be a very instructive device and it was not long before a larger tunnel, 12ft in diameter and having an air speed of 30ft per second, was built for regular use. Experiments with it were quite fascinating to watch, and records of the motion could be obtained, if desired, on cinematograph films for subsequent study in detail.

Another fine performance which seemed to the writer to reflect much credit on the R.A.E. Instrument Division (especially on Bygrave and Meredith) was the birth of "George"—as Britain's first automatic-pilot mechanism was called. This arose from the need for a small pilotless aircraft which could usefully serve as a radio-guided target for A.A. gun practice. It was in some ways akin to the designs got out in America for a possible gyro-controlled flying bomb—which the U.S.A. never used, of course. "George" and his descendants gained much popularity through affording very necessary rest to pilots engaged on very long flights for military or civil ends.

Farnborough's share to-day in the vitally important work of guided missile development is much in people's minds, but on this the author cannot write, though no one with knowledge of R.A.E.'s splendid work during the past fifty years can doubt that it is well able to give unrivalled advice on that immensely complicated problem.

To the general public Farnborough was first simply the location of the Army Balloon Factory, but when the airplane arrived the same location was chosen for the new Royal Aircraft Factory, or, more briefly, the "R.A.F.," though when some years later those initials were used to denote the Royal Air Force, Farnborough received the new title of "Royal Aircraft Establishment" (or the R.A.E.) under a civilian superintendent. Soon after the first world war, when Sir Samuel Hoare (now Lord Templewood) was Secretary of State for Air, the headquarters direction from the Air Ministry was divided between the newly appointed Directors of Scientific Research and of Technical Development, and for greater convenience the Farnborough staff were divided into two main groups—scientific and technical officers, the latter being normal civil servants and the former linked with the F.S.S.U. so as to simplify interchange with the universities. General scientific and technical advice on the experimental work carried out was available from the Aeronautical Research Committee (whose first very distinguished president was the late Lord Rayleigh), and on this the D.S.R. and D.T.D. also served. And as the Director of the National Physical Laboratory at Teddington was also a member of this committee, the aeronautical work of these two establishments could be fully co-ordinated. The committee was fortunate in having among its members a number of scientific men with first-hand air experience, such as R. V. Southwell, B. M. Jones and H. T. Tizard (who later became its chairman). It was due to Lord Haldane that this research committee had been created in 1909 and, at the same time, he had the foresight to see that the National Physical Laboratory must have an aerodynamics division of its own. In its essentials this move was followed by the U.S. Government, which, in 1915, set up a National Advisory Committee for Aeronautics, and not long afterwards Canada and Australia followed suit. In this country aircraft firms carry out research with their own wind tunnels and test houses in relation to their special problems; universities undertake exploratory work with the wider horizons to which they are accustomed. In one way or another, much of the aeronautical research in Britain, as in U.S.A., is sponsored by the Government; whether it be long-range investigations aiming at the finding of new methods of solving old problems, or short-range ones seeking a cure for some immediate ill.

It was a happy chance for me that during part of the year 1914 I became a member of the R.A.E. scientific staff, and was the better able in the following year to accept an invitation to transfer to naval aviation (with its experimental stations at Calshot and the Isle of Grain); hence I found myself in a good position to compare the two services in their friendly rivalry in the field of aviation in the first world war, and even to note when on occasion they seemed to find a little difficulty in remembering that they were really fighting on the same side! But, in due course, the R.N.A.S. and the R.F.C. became very happily merged into the wider horizons of the R.A.F.

* Formerly Director of Scientific Research, Air Ministry.

MONOPOLIES COMMISSION AND STRUCTURAL STEEL FRAMES.—The Board of Trade has referred to the Monopolies and Restrictive Practices Commission the supply of steel frames which cost more than £2500 each for buildings. The Commission is to report about both the facts of the matter and their bearing on the public interest.

Use of Electricity in the Steel Industry*

By W. F. CARTWRIGHT, D.L., J.P., M.I.Mech.E.†

The purpose of this paper is to study the way in which the iron and steel industry affects the national electrical generating industry now, and how it may affect it in five and ten years. The iron and steel industry affects the national consumption of electricity not only by the amount it consumes, but also by the amount that it generates, particularly from surplus blast-furnace gas. The industry is not expected to install large plant for generating from oil or coal as a normal operation. Gas turbines will be used undoubtedly for blowing blast-furnaces and generating power, and may occasionally be used for blowing converters, but they are not suitable instruments for variable load.

THE Central Electricity Authority is obviously interested in the amount of electricity the iron and steel industry is going to require from them in five and ten years' time. The most important factor will be the size of the industry. There is no known method of calculating this with any degree of certainty. Since the end of the war there has been an unsatisfied demand for steel in the country and there has also been an unsatisfied demand in the export market, which makes it very difficult to judge what would have been the production if all demands had been met. In the United States during 1954 all home demands were met. Assuming that there is no material alteration in the tonnage of steel exported and assuming that the national income increases as forecast by the Chancellor, it seems logical to suppose that the rate of steel increase will continue as it has over the past ten years. Then, by 1965, the home and export demand of crude steel together would amount to between 25,000,000 and 27,000,000 tons.

Clearly the above assumptions can easily be upset by such things as war, national restriction on import of our products, and the penetration of the fields now exclusively occupied by iron and steel by light alloy or plastics. To take one case alone, should either the field of containers or motor-car bodies be seriously attacked by the light alloy industry, it would make a large difference to the above figures. Just as the price of electricity will have an effect on the methods and cost of steel production, so must the cost of power have a large effect on the light alloy industry and the relative price of light alloy and steel. For the purpose of this paper, we have assumed that the production in 1960 will be 23·75 million ingot tons, and in 1965 will be 26·8 million tons.

It has been assumed that by 1960 the majority of steel will be produced in integrated works and, therefore, blast-furnace gas will be used where possible for heating coke ovens, mill furnaces and the like, before allocation to power generation, but as, undoubtedly, there will still be some non-integrated works in operation by that date, the method of calculation which has been adopted will probably show less generation than would be the case in actual practice. For instance, in the case of a non-integrated plant with a steel works in Sheffield burning coal or oil on its soaking pits and a blast-furnace plant supplying it with pig iron, perhaps situated in Lincolnshire, there would be more gas available for power generation than if they had been integrated. On the other hand, there are other uses for blast-furnace gas which may have been developed by then, such as the dilution of coke-oven gas used in the national gas grid.

The amount of blast-furnace gas which is available for generation and the power which will be generated from it depends primarily on the coke consumed by the industry, and this, in turn, will depend on the pig iron production. Home ore requires more coke per ton of pig iron than foreign ore, and the calorific value of gas produced on a furnace with a high coke consumption is higher than on a furnace with a low coke consumption. Table I indicates the quantity of electricity which may be generated within the industry.

In preparing Table I a number of important estimates have to be made. Since blast-furnace gas production fundamentally depends on the total coke consumption and this, in turn, depends on the pig iron production, it became necessary to estimate the quantity of pig iron which will be produced in 1960 and 1965. This has been arrived at by assuming that there will be no major increase in capital scrap and that, in fact, it will only increase from 1·6 million tons in 1952 to 2·5 million tons in 1965. Thus the major proportion of raw materials required for the increase in steel production must be found from pig iron.

TABLE I—*Generation Within the Iron and Steel Industry*

	1953	1960	1965
Ingots produced × 1000 tons	17,608·5	23,750	27,000
Pig iron produced × 1000 tons	11,175·0	16,900	19,200
Coke consumed × 1000 tons	12,200	15,630	16,320
Coke/ton of pig iron (cwt)...	21·18	18·5	17·0
Total B.F. gas produced, cu ft × 10^6	1,769,000	2,266,350	2,366,400
Calorific value of B.F. gas, B.Th.U. per cubic foot	105	100	98
Percentage :			
Used for stoves	18·6	19·6	20·0
For coke ovens	23·5	27·0	27·9
For blowing	14·2	13·7	12·5
For furnaces	16·0	17·7	19·6
For process steam	8·9	8·9	8·9
Available for generation...	9·8	6·1	6·1
Wasted	9·0	7·0	5·0
Efficiency of generation, per cent	20·0	22·5	25·0
Total units generated from B.F. gas × 10^6	1,066·6	911	1,036
Probable units generated from coal and oil × 10^6	704·5	950	1,110
Total generation within the industry in units × 10^6	1,771·1	1,861	2,146

With the passage of time coke consumption per ton of pig iron will be reduced as shown in the table, the efficiency of the generation will improve and the use of blast-furnace gas for heating purposes will undoubtedly be extended. These factors have been taken into consideration when preparing Table I, but there is a major difficulty in making any estimate of the power which will be generated by the industry from fuel oil and coal. It seems highly illogical for fuel oil or coal to be burnt in the relatively small boilers of the iron and steel industry when they could be burnt and used with greater efficiency in the large-scale installations of the C.E.A. Nevertheless, there are a number of iron and steel works already fitted with coal-burning installations and undoubtedly the burning of coal or fuel oil to eliminate peaks in maximum demand will continue.

An extract from an iron and steel works maximum demand sheet shows how the burning of oil for a period of an hour and a half kept the maximum demand down by 13MW. In this particular case the normal generation from blast-furnace gas was 22MW, but due to trouble on two blast-furnaces at once it was only possible to generate 5MW.

In cases such as this the burning of oil for generation is well justified. We have assumed that the amount generated from fuel oil and coal will increase in roughly the same proportion as the ingot production, and by estimating the amount of power produced from blast-furnace gas in 1955 have, by difference, arrived at the amount generated from fuel oil and coal, and applied the increase to that figure.

The consumption of power in the industry is dealt with in Table II. In the case of coke and pig iron, we do not expect any great variation in the units per ton. The effect on the consumption of power will be considerable, due to the increase in the quantity of coke produced by the industry and the quantity of pig iron consumed per ton of ingots.

Steel-making processes now in use are open hearth, basic Bessemer, acid Bessemer, electric arc and induction furnaces. Shortly there will be a considerable extension in the use of various forms of oxygen-enriched blast for basic Bessemer steel production.

In this country electric arc furnaces are used extensively for the manufacture of alloy steels, while in the U.S.A. large capacity furnaces for tonnage steel, comparable in size with the largest open-hearth furnaces, are an accomplished fact. The latest furnaces, of which there are two at McLouth Steel Corporation, are of 200 (short) tons capacity ; each is supplied via a transformer of 25,000kVA capacity with arrangements for increasing this rating to 33,000kVA, using heat exchangers. Assuming a 100 per cent cold charge, the electric furnace is very much faster than the equivalent open hearth, and can keep pace with an open hearth on a 60 per cent hot metal charge.

It is not expected that there will be any material change in the power consumption per ton of ingots in open hearth. The power consumption per ton of basic Bessemer steel is difficult to predict, as if, for instance, steam turbines are used for the oxygen plants and much use is made of the oxygen/steam process, the power consumption will be low compared to a plant running on, say, oxygen-enriched air, in which the main blower is electric and the oxygen plant is also using electric power as its main prime mover.

The section of the industry which most affects the electrical industry is the rolling and processing side. The introduction of wide strip mills and cold reduction mills for producing deep drawing sheets and cold reduced tinplate is having a very major effect, first, because the old sheet mills and old tin mills they are replacing were, many of them, driven by old steam engines and, secondly, because the consumption per ton of a cold reduced mill is, for obvious reasons, extremely high.

Quite apart from the introduction of these cold reduction processes, there is a definite swing towards lighter sections and lighter plates in the remainder of the industry. These increases in production of the lighter sections have been seen to a very marked extent in the United States.

At the bottom of Table II is seen the summary of the estimated consumption of power within the industry, the generation within the industry and, therefore, the net demand on the C.E.A.

TABLE II—*Estimated Production* 1960 *and* 1965 *Within the Industry of Coke, Pig Iron, Ingots and Rolled Products*

U.K. iron and steel industries electricity requirements, 1960 and 1965		1960			1965		
		Tons	kWh/ton	kWh	Tons	kWh/ton	kWh
Coke produced within the industry		11,930,000	30	357,900,000	12,620,000	32	403,840,000
Pig iron (includes home ore supplies)		16,900,000	100	1,690,000,000	19,200,000	105	2,016,000,000
Steel ingots...	Open hearth	18,800,000	20	376,000,000	21,370,000	23	491,510,000
	Bessemer...	2,350,000	50	117,500,000	2,670,000	70	186,900,000
	Electric	2,350,000	700	1,645,000,000	2,670,000	700	1,869,000,000
Rolling processes ...	Ingot to slab and bloom	23,750,000	23	546,250,000	27,000,000	25	675,000,000
	Ingot to other products...	350,000	10	3,500,000	375,000	10	3,750,000
	Bloom or slab to section over 3mm	6,150,000	48–85	472,500,000	6,570,000	52–90	522,750,000
	Bloom or slab to section under 3mm	12,350,000	50–350	1,700,110,000	14,070,000	60–360	2,113,000,000
	Other products	4,800,000	10–128	60,566,000	5,275,000	12–150	76,080,000
	Total kWh			6,969,326,000			8,357,830,000
	Less kWh generated within industry (see Table I)			1,861,000,000			2,146,000,000
	Total kWh supplied by C.E.A. to industry			5,108,326,000			6,211,830,000

* Paper. British Electrical Power Convention, Brighton, June, 1955.

† Assistant managing director, The Steel Company of Wales, Ltd.

for 1960 and 1965. The actual power consumption in the industry from 1948 extended to 1965 would indicate a higher consumption than arrived at from Table II.

It is interesting to imagine the form which iron and steel manufacture may take in, perhaps, say, twenty years' time when the cost of nuclear power may have dropped considerably, when coking coal may have become expensive and in short supply, and when the world's resources of fuel oil may be running low. Under such circumstances electricity will play a far larger part in the manufacture of iron and steel in Great Britain than it has done hitherto. In many countries hydro-electric power is used to replace the normal coke blast-furnace.

The largest electric smelting plant yet to be built is nearing completion at Mo i Rana, in Norway, where there will be three furnaces of the Tysland-Hole type, each producing 60,000 tons of pig iron a year. The input to each of these furnaces will be about 18,000kW, the electrodes being of the submerged Soderberg type. There is comparatively little coke addition with a proportionately smaller gas make as compared with the orthodox blast-furnace. The latter, however, is compensated to a certain extent by an increase in the calorific value of the gas.

The introduction of electric smelting plant considerably alters the fuel balance in an iron and steel works, and it is possible that under such conditions, electrically heated soaking pits and annealing furnaces will supersede the gas/oil-fired industrial heating equipment presently in use. It is instructive to compare two fully integrated iron and steel plants, the one with present-day methods of production and a flow, the other using electricity in the fields hitherto satisfied by open-hearth and blast-furnaces. Both plants have a weekly production of 30,000 tons of pig iron and 48,000 tons of ingots. From the latter, 40,000 tons of hot strip and plates, 30,000 tons of cold reduced material, tinplate and sheets, 5000 tons of thin plates and 5000 tons of heavy plates would be made. In the "all-electric" works, the entire production of pig iron would be obtained from electric smelting furnaces, and 20,000 tons of steel from electric arc furnaces, with the balance of 28,000 tons from basic Bessemers.

In a typical electrical layout for the "all-electric" works a bulk supply might be taken from the Central Electricity Authority's transmission system at 275kV. An attractive alternative might be to have a C.E.A. power station integrated with the iron and steel works. Indeed, such an arrangement would seem ideal in some respects as the station would then be sited at the load centre, and common services could be provided for both projects. However, possible objections could be :—

TABLE III—*Comparison of Annual Fuel and Electricity Requirements of Orthodox and "All-Electric" Iron and Steel Works*

Type of fuel		Orthodox integrated plant	"All-electric" integrated plant
Coke-oven gas (490 B.Th.U./cu ft)		$18{,}540 \times 10^6$ cu ft	$10{,}515 \times 10^6$ cu ft
Blast-furnace gas (95 B.Th.U./cu ft)		$180{,}960 \times 10^6$ cu ft	Nil
Electric smelting gas (287 B.Th.U./cu ft)		Nil	$33{,}072 \times 10^6$ cu ft
Tar		39,520 tons	22,410 tons
Coke, beans and breeze		1,386,480 tons	707,720 tons
Heavy fuel oil		193,070 tons	Nil
Waste heat steam		$2{,}044 \times 10^6$ lb	Nil
Works electricity generation	Output	127×10^6kWh	Nil
	Power factor	0·75 lag	
	Maximum output	21MW	
C.E.A. electricity supply	Import	721×10^6kWh	$5{,}157 \times 10^6$
	Power factor	0·97 lag	0·83 lag
	Maximum demand	117MW	648MW
Total electricity supply	Consumption	848×10^6kWh	As above
	Power factor	0·95 lag	
	Maximum demand	138MW	

(1) The difficulty of finding a suitable site with adequate cooling water facilities.

(2) Civil engineering costs might be very much greater than for an alternative site situated some distance from the works.

(3) The comparatively small size of the turbo-alternators which would be required. By the time such a scheme could become a practical proposition one imagines that sets of the order of 500MW would be in commission.

Comparative figures of power consumption and maximum demand, together with usage of solid and liquid fuels and blast-furnace gas, are given in Table III. These figures show what a tremendous impact the iron and steel industry could have on the electrical generating industry if and when cheap supplies are available.

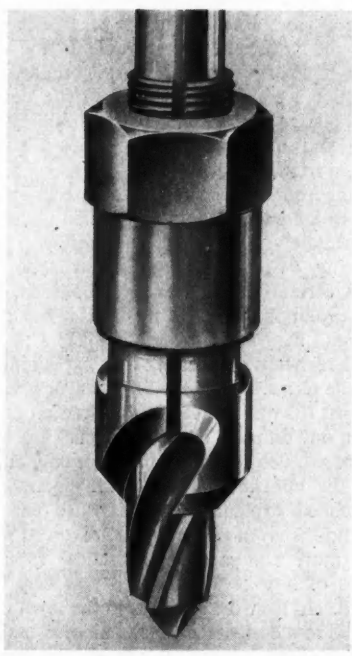
The electric smelting furnace equipment would consist of 66kV air blast circuit breakers controlling 75,000kVA furnace transformers having on-load tap-changing, and a transformation ratio of 66,000/300V. Electrode currents would be of the order of 140,000A. It is appreciated that currents of this magnitude present a formidable problem to furnace designers, and it is envisaged that such furnaces would probably have a minimum of twelve electrodes in line, with possibly two lines. The furnaces would each have an output of 500 tons per twenty-four hours. Furnaces of the three-electrode type are operating in this country designed for electrode currents in excess of 80,000A.

The submerged arc furnace provides a relatively steady load and taking into account the diversity factor of the whole installation, together with the smoothing effect of modern quick-response automatic electrode control, no untoward effect on the supply system would result from a furnace load of this magnitude.

Continental Engineering News

Combination Countersink

Our illustration shows a combined drill and countersink, which is manufactured by Werner Roterberg Procedo-Werkzeugfabrik, Duesseldorf, Karlstrasse 100. In this device, which is made for twist drills of 2mm to 20mm diameter the drill is clamped between the two high-speed steel countersink cutters by means of a conical collar held tightly by a nut. Drilling and countersinking can be performed in one operation. The countersink cutters are easily reground ; carbide-tipped cutters are available. By using the appropriate shape of cutter a variety of countersunk or counterbored holes can be produced. Instead of clamping the drill in a chuck, the device can be screwed into a conical arbor, the arbor taking the place of the clamping nut. In that case short or broken drills can also be used. The cutting torque tends to tighten the assembly and to grip the drill firmly. Run-out is stated to be of the order of 0·01mm. An adjustable depth stop is available for this device, which is handled in this country by Thoka Machinery Supplies, Ltd., 2, Drapers Gardens, London, E.C.2.



Combined drill and countersink. The two cutters are clamped to the drill by a collar and can easily be reground

Taxation of International Road Transport

At a recent meeting of the E.C.E. Working Party on Fiscal Questions, proposals were adopted for the liberalisation and unification of taxation of road transport in Europe. Most of the Western European countries at present give tax exemption to foreign private automobiles for a period of up to three months. This period was fixed by a convention of 1931. It is now proposed to make the period of exemption coincide with the validity of the foreign vehicles' temporary importation papers, subject to each state having the right to set a limit of 365 consecutive days. This matter has been incorporated in the text of a draft convention which is to replace that of 1931. It is, however, suggested that the E.C.E. sub-committee on Road Transport adopt a resolution recommending the immediate application of this provision, in order that its advantages may be enjoyed by car users without having to wait for the formal coming into force of the complete convention. The experts also examined the question of double taxation in international passenger and goods transport. Double taxation may occur : (i) through circulation taxes being levied on the same vehicle in different countries, or (ii) through transport taxes being levied on the same transport by different countries, or (iii) through fuel taxes being levied on fuel imported in a vehicle which had already been taxed in the country of departure. The majority of government representatives at the E.C.E. session agreed to apply the provisions for private cars also to the circulation of foreign motor coaches. Certain governments were even prepared to abolish all taxes on the circulation of foreign lorries. Agreements regarding commercial vehicles, however, present more complicated problems than those affecting private cars, therefore, any such agreements will be formulated separately for the two classes. No double taxation was found to exist on the international transport of the goods or passengers themselves. The question of fuel taxes is expected to be dealt with by the E.C.E. Working Party of Customs Experts which is due to meet in August. In practice, exemption is granted for fuel contained in the normal tanks of the vehicle.

Short Notice

Analysis of Deformation. Vol. II. By Keith Swainger. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 70s.—Volume I of this treatise formulated the theory of the analysis of deformation. It contained a rigorous mathematical treatment and imposed certain idealising restrictions. In Volume II this theory is applied to practical cases and related to experimental results. The practical aspects sometimes necessitate departure from rigorous theory ; but any approximations that are made are indicated. Despite the introduction of this practical aspect, the book is in the main a theoretical treatise with a considerable amount of mathematical analysis. The following subjects are covered : one-stress tests and theoretical considerations, homogeneous plane and curvilinear two-stress systems, heterogeneous two-stress experiments and theoretical examples, three-stress analyses, interpretation of rubber deformation, couples applied to massive bodies, shearing thin plane laminæ. There are four appendices : vector analysis, complex variable, finite differences, Fourier series. At the beginning is a list of the principal notation ; at the end a glossary of technical terms. There will be many engineers and physicists researching in some aspect of this important subject for whom this book will be of value.

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GREATER ECONOMY IN STRUCTURAL DESIGN

About two months ago we published a leading article on open days, commenting on the usefulness of such occasions. There was little need to seek a reason to justify the open days held by the Building Research Station early this week, for the Station discarded the disinterestedness which might be expected from a Government research establishment on such an occasion, and was plainly "selling" something—a fact which it was polite, but insistent, about at the Press preview. The Building Research Station considers that more use could be made of improved methods in structural design, and in particular the "load factor" concept should be more widely applied. The open days were arranged to demonstrate that point of view, and to try and obviate the discouraging situation of seeing useful research discoveries ignored in application. The trouble lies not with codes of practice, which already contain, or are being modified to contain, clauses which permit a choice between established design methods and newer approaches such as those which the Station advocates. The new methods simply are not used frequently enough. At a time when there is such a great deal of constructional activity, and there are many other innovations such as new materials, with which to be conversant, many structural designers have not the time to master new design techniques, it appears, nor to introduce them into their drawing-offices. It is often thought, too, that economies are attained only at the cost of increased drawing-office time, and there is none to spare.

The example which springs to mind particularly to illustrate this dilemma is the design of steel frames for multi-storey buildings—a particularly intractable problem in theory. We have to go back to 1929, when the Steel Structures Research Committee was appointed, for the beginnings of the present attempts to improve steel-framed building design. The committee's later findings, published before the war, were largely ignored in practice, because it was considered that the economies obtained did not warrant the increased complexity of design. During the past few years attention has been drawn to the collapse method of design, which takes account of the plastic as well as the elastic behaviour of structural steel. But although this method is finding increasing application in practice, it is not yet sufficiently advanced to be used, as part of a normal design office routine, for multi-storey steel frames. The Building Research Station ascertained, from site measurements, that the stresses in a steel frame of this kind were markedly less than those computed in practice according to normal elastic design methods, so it set itself the task of finding out why, and of introducing economies in elastic design to utilise the reserves of strength resulting from this discrepancy. Such economies, it was contended, could be applied in design immediately, without interfering with existing design methods. This task has to a certain extent been accomplished, but the evolution of a new method, it has been found, has not proved sufficient; the method needs publicising and explaining in simple terms. Thus the first of a new set of reports (its title is given in our account of the open day on page 112 of this issue) has been prepared, describing the first economy aimed at—the contribution of "stiff" joints; a simplified explanation of how to use the method is given in the report, divorced from the more complicated theoretical explanations of how it was evolved and why it is valid. In fact, the report is in the form most suited to a designer's use, the method making use of charts which it is claimed are easy to understand and apply. A second report on a simplified method for utilising the plastic strength of columns is in preparation. Another important economy concerns the load-bearing capacity of the concrete encasement, normally provided in a steel-framed structure for fire protection, but not normally taken into account in the structural design. Measurements made by the Station have shown that a substantial part of the load in a column is taken by the encasement. Other factors, such as panel infillings and floor slabs, add to the strength of the structure, too. The same kind of reasoning applies generally to reinforced concrete structures as well as to steel ones, as we have indicated in our article on page 112. In formulating a code of practice for prestressed concrete, however, it has been found that the "load factor" approach is more readily made use of; there is no "traditional" background with such a new material.

The Building Research Station's "simplified" designs will, we think, demonstrate that greater economy in structural design does not necessarily result in greater complexity in the actual design computations. In fact, the reverse may be the case. In considering the "load factor" approach the structure as a whole must be understood more thoroughly. Then it may be that some qualifying assumptions are no longer necessary, and the simplicity of the design work may be enhanced. Consider, for instance, the design of a slab. Anyone who has studied a strength of materials textbook will recall shying away from the abstruseness of the chapters on slabs. The Building Research Station has carried out tests on reinforced concrete slabs, supported along their edges on steel beams, as they would be in a steel-framed building. The tests fall in the two categories of "stiff" perimeter beams and "elastic" perimeter beams, the latter deflecting with the slab. Each gives a characteristic failure. The "stiff" beam case, for instance, fails with cracks across the diagonals of the slab; having established this fact, the failing load may be simply expressed by considering the equilibrium of a quarter-slab, and evaluated in a few lines. Such welcome simplifications result only from a full understanding of the way structures behave, and are apparent only after laborious research, involving full-scale measurements of stresses in buildings or carefully chosen programmes of testing. In some cases elaborate analysis may be necessary to evolve a comparatively simple design routine, as the use of a digital computer exemplifies in the Station's work on stanchion design in steel-framed buildings. The final result is, however, a more rational use of structural material and hence greater economy in the structure. If the full benefit is to be obtained, the new methods need to be widely applied, and it is for this reason that we hope the Building Research Station's venture into "salesmanship" will be as successful as its researches undoubtedly have been.

RAILWAY TRACTION

No meeting of engineers concerned with railway traction by internal combustion engines has been more representative, or convened at a more opportune time, than was the meeting recently held at The Hague. As many as fourteen papers were submitted in Group "A" (Railway Traction) and for the first session the chair was taken by Mr.

F. Q. den Hollander, who, as President of the Netherlands Railways, was peculiarly well chosen to preside on such an occasion. It is altogether desirable that at a time when many problems are awaiting solution there should be unfettered discussion among those best able to express opinions and —more important—to support such opinions by experience and enlarge them by enterprise. The traction oil engine is, however, no new thing since rather more than 67 years ago Lord Kelvin—then Sir William Thomson —reporting (March 7, 1888) on the Priestman oil engine mentions that "A small double-cylinder engine has been mounted upon a truck, which is worked on a temporary line of rails to show the adaptation of a petroleum engine for locomotive purposes." In 1894, Priestman built a four-wheeled shunting locomotive for standard gauge, this locomotive having a 30 b.h.p. two-cylinder double-acting vertical oil engine, speed 300 r.p.m. It was used for shunting purposes at Hull and has been rather overlooked in connection with the history of oil-engined locomotives. The petrol-electric railcar goes back more than half-a-century; the first serious attempt to utilise the diesel engine in a main line locomotive dates from 1912 and in 1913 there was put into service what may have been the first diesel-electric railcar. It was fitted with a 75 b.h.p. 6-cylinder (air-injection) engine, speed 600 r.p.m. and was still at work in 1933. These early examples are mentioned in order to assist in removing a prevalent impression that the oil engine is something new in traction equipment. It is true, of course, that the development of the oil-electric locomotive has been particularly active during the past fifteen years until, at the present time, it is usual to speak of the steam locomotive as "on the way out." Indeed, in the United States the spectacle of a steam locomotive hauling a passenger train or a freight train has already become rather rare. Here in the United Kingdom—where the question of rail traction is now a matter of crucial importance—the subject of internal combustion engine traction has to be considered in the light of circumstances differing very greatly from those obtaining in the United States. A recent article in *General Electric Review* calls attention to the diesel-electric locomotive "evaluation" now in progress. "Important to both builders and operators, this will determine what changes should be made in locomotives purchased either as additions or as replacements. The concluding step could be the emergence of a new type of self-propelled locomotive sufficiently superior to ultimately displace the diesel-electric. Competitive types are appearing from several different directions, all contending against the solid background of diesel investment and experience." It is thus the more opportune that we should have, at the present time, the benefit of such an exposition of—and discussion on—"competitive types" as that presented during the conference recently held at The Hague.

Among many other matters on which considerable light was thrown was that of maintenance, a subject of serious consequence in the United States where to-day there are said to be upwards of 27,000 diesel-electric locomotives in service. It is surely true that in the evaluation of the "competitive types," a major consideration must relate to maintenance. One can realise, for example, the shop facilities required in the United States for effecting (*a*) complete engine repairs; (*b*) complete electrical repairs. One contributor to the symposium at The Hague remarked that a facility "not generally found in an American railroad repair shop is the crankshaft grinder. The original cost of one of these machines is so considerable that only the largest of the railroads have purchased them, though the railroads so equipped have made the services of these grinders available to others in the railroad industry." Discussion at The Hague revealed considerable difference of opinion as to the mounting of engines below vehicles and also as to mounting them on bogies. While there is general unanimity in respect of the movement towards higher engine speed, it is recognised—as one speaker of great experience remarked—that "with too high a speed problems arise which lower safety of operation and economy decisively. At a certain degree of development an upper limit of speed exists for each project." It appears, moreover, that definition of the continuous output of an oil engine is still a controversial matter, nor is there, apparently, any general agreement as to (1) when an engine can be deemed to be "run-in" or (2) the "running-in" procedure as regards piston rings and cylinder liners. There does seem to be a consensus of opinion in favour of standardisation of the dimensions of diesel engines in various categories. This would tend to facilitate the standardisation of parts, notably those parts of rail traction and vehicle engines which are subject to the highest mortality.

Even while the conference at The Hague was in session the *Revue Générale Des Chemins De Fer* published certain information which must provoke the serious attention of railway administrators and engineers throughout the world. This referred to the performance of two S.N.C.F. main line electric locomotives during extra high-speed tests carried out on the Lamothe-Morcenx section of the Bordeaux-Hendaye line. Hauling three carriages, each of these locomotives attained a speed of 331km per hour (205 miles per hour). The tests were carried out with standard C_0-C_0 and B_0-B_0 locomotives weighing, respectively, 107 tonnes and 83 tonnes. The train weight in each case was 103·5 tonnes. That standard locomotives intended for a normal maximum speed of 140km per hour could, with an alteration in gear ratio, the use of solid monobloc steel wheels and the fitting of special pantographs, attain a speed of 331km per hour leads to the recognition—as perhaps the most important deduction—of the great safety margin possessed by the traction equipment thus tested. The designers and manufacturers of internal combustion engined locomotives are obliged to keep in mind the ever-increasing demand for high power, a demand which has to be met without undue encroachment on safety margins. This is certainly emphasised by the details of the tests at Morcenx, which show that the maximum power at the pantograph went to 8200kW in one case and to 9400kW in the other. The intensive development now proceeding in the field of oil engine traction cannot but be stimulated by the recent achievements of the electric locomotive and the knowledge that this kind of traction unit, intended for a maximum speed of 140km per hour is able, without alteration or accident, to reach a speed very considerably higher.

Literature

Fluid Dynamics of Jets. By SHIH-I PAI. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 37s. 6d.

THE purpose of this book is to present the experimental and theoretical facts about the steady flow of a jet of gas issuing from a nozzle into a surrounding stream which is at rest or in uniform motion. It is intended as an introduction for advanced students and as a work of reference for scientists and engineers engaged on design and research.

The chapters are arranged according to the character of the flow. Chapter I deals with the inviscid and incompressible fluid of classical hydrodynamics, while Chapters II and III admit compressibility first for subsonic and secondly for supersonic jets. The remaining six chapters admit viscosity of the fluid and deal in turn with laminar flow, turbulent-incompressible and turbulent-compressible flows, and the jet mixing of gases of different kinds, with two final chapters on the stability of jets and the conditions under which transition from laminar to turbulent flow occurs. There is an appendix containing the fundamental equations of fluid dynamics. Much more space is devoted to theoretical attacks on the various problems than to experimental results.

Although this book is restricted to a particular topic in fluid mechanics, nevertheless the problem of jet flow occurs in connection with many pieces of apparatus and on that account this connected treatment of the subject will be welcomed by many designers and research workers. A useful list of references is given with each chapter. Over and above the collection of theoretical and experimental results contained in a book of this type one is entitled to expect that the results shall be integrated into the body of knowledge of fluid mechanics in general. Each particular result can best be understood and appreciated in the light of general principles which, in turn, are illuminated by the particular result. It is in this respect that a book by Prandtl can be so satisfying and that the present one is rather disappointing. It is a collection of results without the perspective. There are also, unfortunately, a number of erroneous or careless statements. For example, equation 2.7 is not restricted to reversible flow and one had hoped that this confusion about the thermodynamic aspects of flow had ended. It is unusual to see the Prandtl number defined as the reciprocal of the Stanton number, and if the Prandtl number is merely "a measure of heat conduction," why does it involve specific heat and viscosity? The Peclet number, which involves density and velocity among other things, is also said to be a measure of heat conduction. There are serious errors in Figs. 3.15 and 3.17, where oblique shock waves are shown deflecting the flow towards the normal to the shock wave instead of away from it.

While this book can therefore hardly be recommended as general reading for the student of fluid mechanics, nevertheless it provides for specialists a very useful collection of information on the particular subject of flow in jets.

Obituary

SIR RICHARD WILLIAM ALLEN

ENGINEERS in many fields, the engineering industry and many technical institutions, have suffered a great loss by the death of Sir Richard W. Allen, which occurred on Sunday, July 17th, and his death will be keenly felt by W. H. Allen, Sons and Co., Ltd., the engineering firm of which he was chairman. His passing breaks another link with the pioneering days: it means the loss of a notable leader and worthy successor to his father, William Henry Allen, the founder and first chairman of the company which bears his name, and which has taken a leading part in the development of mechanical, electrical and hydraulic engineering. Sir Richard, who was in his eighty-ninth year, had spent nearly seventy years in the engineering industry and was well known by the Engineers-in-Chief of the Fleet, the leading British shipbuilders and the leading personalities in the shipping industry. However, although closely associated with the design and construction of auxiliary machinery for naval and merchant ships, Sir Richard was interested in many land engineering projects which covered such items as pumping schemes for land drainage and irrigation, water supply and sewage disposal, as well as generation of electrical power in various stations and in industrial plant at home and abroad. Such wide interests were in character with the tradition of his company, which has been engaged in the design and construction of pumping and power generating machinery since it was founded in 1880.

Sir Richard, who was the eldest son of William Henry Allen, was born at Cardiff on February 1, 1867, and was educated at Christ College, Finchley, London. His technical education was the responsibility of Dr. Gisbert Kapp, who, with others, did much to place dynamo design on a sound scientific basis. Later, Richard Allen served an apprenticeship with W. H. Allen and Co., which his father had founded at York Street, Lambeth, and there he passed through the various shops. In those days the main business of the firm was centrifugal pumps, but the development and production of mechanical and electrical products in combination was already under consideration. Soon the company was manufacturing a wide variety of engineering products, including steam engines, electric generators and motors, and these activities provided invaluable experience for Sir Richard. He widened his experience by spending two years—1887 and 1888—in the drawing-office of John Elder and Co., now the Fairfield Shipbuilding and Engineering Company, Ltd., on the designs of marine engines. This was supplemented by a further eighteen months with the Naval Construction and Armaments Company, now Vickers-Armstrongs, Ltd., at Barrow in Furness, where, in addition to work on marine engines, he assisted in the laying out of new engine and boiler works. There followed a short period of service at sea as an engineer on board the Cunard liner S.S. "Etruria," and then in 1890 he went to the United States, where he paid visits to works engaged in shipbuilding, electrical engineering and tramway construction.

On his return to England he became assistant manager in the York Street works under his father. These were now proving inadequate to deal with the increasing volume of business and the site was sold to the London and South-Western Railway Company, to become what is now Waterloo Station. By 1894, Mr. W. H. Allen had transferred the business to the Queens Engineering Works, Bedford, and, at the same time, made his son a partner, and the firm became known as W. H. Allen, Son and Co. Six years later limited liability was assumed, and then twenty years later, in 1920, there was a further change to the present title of W. H. Allen, Sons and Co., Ltd.; the firm remained a family concern until 1952, when the status of public limited liability was adopted. On moving to Bedford, Sir Richard became managing director of the company and continued as such until the death of his father in 1926, when he took over the duties of chairman, duties which he fulfilled for the next twenty-nine years. Both as managing director and chairman, Sir Richard travelled the world and visited many countries on behalf of his company, and on one of his world tours represented the Universities of Cambridge and London, and the Institution of Mechanical Engineers at the 1929 Tokyo World Engineering Congress.

During his long life Sir Richard rendered valuable service to the profession of engineering and was an esteemed member of many technical societies. He became an associate member of the Institution of Civil Engineers in 1892, a member of the Institution of Naval Architects in 1895 and five years later a member of the Institution of Mechanical Engineers, of which he became vice-president in 1924, and president in 1928, and has been an honorary life member since 1931. He was a past-president of Section G, British Association for the Advancement of Science, and was honoured with honorary life membership by the Japan Mechanical Society. In 1916 he was elected a member of the Institute of Marine Engineers and was also a member of many other societies, including the Iron and Steel Institute, the Institute of Metals, and the Royal Aeronautical Society. He delivered many papers covering a number of subjects, being awarded the Telford Premium by the Institution of Civil Engineering in 1906; they included the following:—"Surface Condensing Plants and the Value of the Vacuum Produced," "Pumping Machinery in the Fens," "Irrigation Pumping Machinery (Gezira Scheme), Sudan," "Improved Designs of Tee-Pieces and Bellmouths for Suction Pipelines of Pumping Plant in Floating Dock," "Air Supply to Boiler Rooms," and The Application of Steam Turbines to Auxiliary Machinery." Auxiliary machinery and equipment for naval and merchant vessels was Sir Richard's special engineering interest, and he designed and patented air supply equipment for the warship boiler-rooms, and his book *The Air Supply to Boiler Rooms for Modern Ships of War* ran into three editions.

Sir Richard W. Allen

Sir Richard was a trustee and vice-president of the Engineering and Allied Employers' National Federation, a vice-president of the British Electrical and Allied Manufacturers' Association, and a member or fellow of many other societies, including the Japan Society, The Pilgrims, Royal Empire Society, Royal Agricultural Society, the African Society, Royal Horticultural Society, Zoological Society, &c.

Sir Richard Allen had a keen interest in technical and scientific education and was concerned with the training of all those who passed through the works under the Allen system. Many leading bodies consulted him upon this question of education, including the London County Council for the Robert Blair Fellowships. Although actively engaged in the direction of his company he found time to take part in the affairs of both town and county, of which he was Deputy Lieutenant, a Justice of the Peace, and High Sheriff of Bedfordshire. He was awarded the C.B.E. in 1918 and for his many and valuable services he was honoured with a knighthood in 1942.

Sir Richard, throughout his life, took a particular interest in the training of young men. During his chairmanship of Allens, the apprentice training scheme which his father had started was steadily improved. The firm, largely as a consequence of the interest he took in the matter, was amongst the leaders in recognising how circumstances were changing and how a more conscious effort to give young men an adequate training was becoming necessary. Very soon after the first world war the premium system was

dropped. A supervisor was appointed whose whole attention was given to apprentices' affairs. The work that an apprentice did, the length of time he spent in any shop or at any bench, was no longer solely controlled by the foreman. A definite policy was adopted of sending out apprentices upon outside erection jobs, sometimes, indeed, in sole charge of them ! Sir Richard laid special emphasis upon the need for young men to be able to express themselves publicly in speech, and his encouragement was always particularly ready for the apprentices' society before which papers were read which the apprentices were expected to discuss. Prize schemes were devised and the awards were made not only for exhibition of skill in the works, but taking into account also recreational abilities, powers of self-expression and sense of responsibility.

Sir Richard, like his father before him, was a benevolent autocrat. He belonged to a generation that had never heard of "Labour Relations" or "Joint Industrial Councils," and the like. He saw to it that those who worked at Allens were healthy, well fed, well housed and had adequate means of recreation. In return he expected—and received—loyalty to the firm and respect for himself. He believed, indeed, that he knew better than the men themselves what was good for them and it is more than possibly true that he did, for even during the years of the great depression Allens was a happy works. At intervals Sir Richard, like a monarch, would make a ceremonial progress through the works attended by a retinue of executives. Upon entering each shop he was "received" by its foreman, who discussed with him work in progress and any difficulties or troubles he was experiencing. Sir Richard would then walk slowly round. He knew all the older hands and would greet them by Christian name and ask about their wives and families. Had anyone a complaint to make now was the time to make it. Given the courage—it required a full measure of it !—anyone could approach Sir Richard and, providing the thing was done respectfully, make his plaint. At once it would be inquired into and, if possible, settled on the spot.

Times have changed. In these more democratic days such methods would no longer work. Men will no longer rely upon the benevolence of so autocratic a figure as Sir Richard. Yet it is worth remembering that Sir Richard was known to his men, though not to his face, affectionately, as "Dickie."

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RESILIENCE OF A GYMNASIUM FLOOR

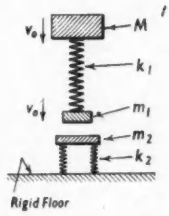
SIR,—It would, indeed, be a pity if those responsible for building school gymnasia were to accept the views expressed by your correspondent, T. R. C-B-Cave, in your issue of June 10th. As this is a matter of some importance to school authorities and may also be of general interest to engineers, I will briefly summarise the letter in question before commenting on it.

The point at issue was whether the preference for a resilient gymnasium floor, as evidenced by the conventional type, is based on "measurable physical properties or is purely psychological"—to quote your correspondent's words. The difference, he points out, between a resilient floor and a solid floor of (say) wood blocks resting directly on a concrete floor, is that the one yields slightly to the shock of a child landing on it or jumping or running, whereas the other does not. The resilient floor is also a good deal more costly, and the main purpose of the experiment, which he describes, was presumably to determine whether or not the extra cost is worthwhile.

The experiment was carried out by two members of the Civil Engineering Department of Southampton University—Dr. Wright and Mr. Ray, in conjunction with staff members of Taunton's Grammar School, Southampton, which "has a first-class gymnasium floor." It was a very simple experiment. A boy weighing 150 lb jumped from a box 3ft 6in high to the floor ; the maximum deflection of the floor was measured and so also was the downward movement of his hips after his feet touched the floor. It was found, after several jumps, that the floor deflection varied between 0·025in and 0·03in, and that the average hip movement was 6in. The conclusion reached was that "As the yield of the boy's limbs was 200 times the yield of the floor, it is difficult to believe that the resilience of the floor has any significant physical value whatever."

This is a very odd conclusion to come to, since the elimination of "measurable physical properties" as a reason for preferring resilient floors apparently leaves only the alternative of a "purely psychological" preference. And this, if it means anything, means that users of a resilient floor would not notice the change if, by some means or other, a hard floor of exactly the same appearance was, unbeknown, substituted for it. The conclusion has only to be stated in this form to make its validity suspect.

Where, in my opinion, the authors of the experiment have gone astray is in thinking that the distance moved through by the boy's hips is in any way relevant to their investigation. Your correspondent states that "the shock upon his body depends inversely on the distance in which its fall is arrested," and goes on to identify that distance with the distance moved through by the hips. Finding that the slight give of the floor (0·03in) is negligible compared



with the 6in movement of the hips, he dismisses it as of no value in reducing the shock to the body. On this argument a give of 0·3in, i.e. ten times the measured value, could almost equally well be dismissed, since it constitutes only 5 per cent of the 6in hip movement. But this is palpably untrue, and at variance with common experience. Where, then, lies the error ? This perhaps may be gathered from the following observations.

In the evolution of man, nature has been at great pains to protect the delicate organs of the body around and above the hips by providing a strong and elastic pair of legs capable of effectively insulating the trunk from ground shocks. The legs above the knee—and to a lesser extent the knees themselves—are similarly insulated by the flexing of the knees and ankles. Parts below the knee, however, and particularly the feet, are much more vulnerable to shock loads from impact with hard ground. In my view the value of a resilient floor lies in its capacity for materially reducing foot shock, whether to the ball of the foot or to the heel, thus not only protecting the feet themselves but also those upper parts of the body which can receive direct shock loads through the heels.

But, one may ask, how can even the feet be protected when the floor deflection is so small ? The answer is that it is not too small to allow the impact between feet and floor to be materially reduced. A simple mechanical system will illustrate my meaning.

The diagram shows a mass m_1 connected by a spring k_1 to a bigger mass M. The spring is unloaded as the two masses descend with the same velocity v_0 towards the mass m_2 supported on springs k_2 attached to a rigid floor. To fix ideas, suppose $m_2=(\sqrt{2}-1)m_1$ and that springs k_2 are much stiffer than spring k_1. Suppose also that the coefficient of restitution for the impact between masses m_1 and m_2 is zero, so that both masses move down with the same velocity immediately after impact. That velocity, by considerations of momentum, is at once given as

$$v=v_0m_1/(m_1+m_2) \quad . \quad . \quad . \quad . \quad . \quad (1)$$
$$=v_0/\sqrt{2}$$

and

$$v^2=v_0^2/2$$

The mass m_1 thus suddenly loses half its kinetic energy on impact with m_2. The two masses m_1 and m_2 are then quickly brought to rest by the strong floor springs, k_2, while the tension in k_1 meanwhile has hardly suffered any change. Eventually, of course, it must absorb as potential energy the kinetic energy of mass M.

The system just described represents roughly the case of the boy jumping from the box to the floor. Thus, M is the mass of his trunk and m_1 that of his feet and the lower parts of his legs, while k_1 is the spring equivalent of his leg muscles. The mass m_2 represents the generalised mass of the floor corresponding to the particular normal mode excited, and the floor springs k_2 represent the elasticity of the sprung floor. Assuming now that the ratio of these two masses is that assumed above, we see that half the impact between feet and floor is absorbed at first contact, the other half being absorbed while the floor deflects. But whether the true fraction is a half or not, the fact remains that the blow to the feet is softened by the initial impact between the feet and the "generalised" mass of the floor. The same remark applies to direct contact of knee or head with the floor, the generalised mass of the floor being then, of course, different.

A very interesting piece of research could be carried out on sprung floors in general, and design rules laid down as a guide to, for example, the rather different requirements of a dance floor and the floor of a badminton court. Of one thing, however, I can speak from personal experience, and that is the radical difference between playing badminton on a solid concrete floor and on a well-sprung wood floor.

D. WILLIAMS
D.Sc., M.I.Mech.E., F.R.Ae.S.
Farnborough, Hants.
June 27th.

Books Received

Magnetic Materials in the Electrical Industry. By P. R. Bardell. London : Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 32s. 6d.

Merchant Ships : World Built. Vessels of 1000 Tons Gross and Over Completed in 1954. Southampton : Adlard Coles, Ltd., 7, Brunswick Place, Southampton. Price 25s.

Principles of Machine Woodworking : Four Cutter Practice. By A. H. Haycock. London : The Technical Press, Ltd., 1, Justice Walk, Lawrence Street, S.W.3. Price 16s.

Introductory Applied Physics. By N. C. Harris and E. H. Hemmerling. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 50s. 6d.

The Testing and Inspection of Engineering Materials. Second edition. By H. E. Davis, G. E. Troxell and C. T. Wiskocil. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 49s.

HEAVY TURBINE SHOP AT ERITH

Fig. 1—New heavy turbine shop at Fraser and Chalmers Engineering Works. In the foreground, left, is a 26ft vertical boring and turning mill. On the right is a 60MW turbine for Ince, erected on the test pit

Fig. 2—Part of the exhaust system of the turbine test and erection pit, showing the 4ft pipes communicating with the 4ft 6in main to the condenser

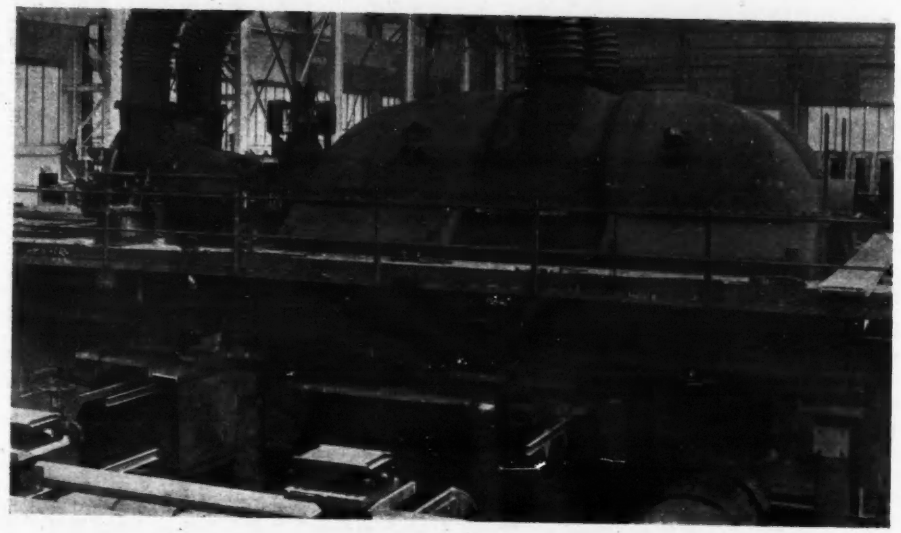


Fig. 3—60MW turbine for Ince power station (Central Electricity Authority) erected on the test pit

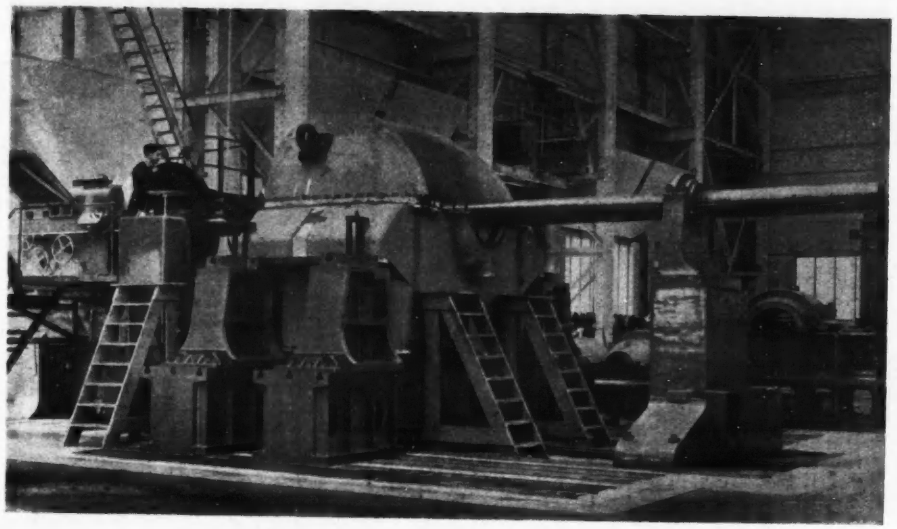


Fig. 4—Bearing ways being bored in a low pressure turbine casing in the new heavy turbine shop

Heavy Turbine Shop at Erith

Last Friday a new shop for the erection and testing of large steam turbines at the Fraser and Chalmers Engineering Works of The General Electric Company, Ltd., was opened by Lord Citrine, chairman of the Central Electricity Authority. The shop has an erection and test pit measuring 91ft by 87ft across the top. This pit is equipped with beams and columns and a tee-slotted bed which constitute, in effect, an adjustable bed-plate capable of accommodating, simultaneously, three turbines of any size at present foreseen. Steam for test purposes is supplied, at any temperature up to 875 deg. Fah., by an International Combustion oil-fired boiler of 45,000 lb per hour capacity at 665 lb per square inch. Some of the machine tools in the new shop are described here.

FOUR years ago, in response to the growing demand for large turbo-alternators, The General Electric Company, Ltd., built and equipped a new heavy plant shop at its Witton engineering works, as described in our issue of Nov. 16, 1951, page 629. Now the company has provided complementary facilities for increasing the production of large turbines at the Fraser and Chalmers Engineering Works, Erith, where a new heavy turbine shop was formally opened on July 15th by Lord Citrine, chairman of the Central Electricity Authority. This new shop, which is illustrated herewith, is designed for the erection and testing of the largest turbines at present envisaged for power generation.

The new turbine shop can be seen in the centre foreground of Fig. 5, immediately to the right of the power station chimneys. It is a steel fabricated building, with brick-filled walls up to 13ft from the ground ; above 13ft the walls and roof are sheeted with protected metal sheeting and lined with plasterboard. As illustrated in Fig. 1, the shop consists of a main bay 364ft long and 131ft wide, with an erection and test pit and a 284ft by 40ft machine tool annexe on one side, giving a total floor area of 59,044 square feet. In the main bay the height is 82ft to the ridge and 59ft to the eaves, and in the annexe 37ft to the eaves. The roof guttering is designed to form a walkway with handrails round the building, level with the eaves. There is also a continuous runway round the building from which cradles can be suspended and shifted as desired for cleaning and repairing the upper windows and sheeting and for painting.

Two 60-ton Wharton cranes with a span of 120ft run on rails extending the full length of the shop at a height of 43ft. Both can be operated in tandem for a lift of 120 tons. In addition to the 60-ton main hoist, each crane has a 20-ton auxiliary hoist and is driven by four 500V d.c. motors operating the two hoists, and the longitudinal and cross traverse. Two of the roof trusses at each end of the main bay are specially designed to accommodate a lifting beam for removal and replacement of crane equipment for servicing.

Turbine Test Pit.—In the centre of the main bay (Fig. 1) is a pit on which turbines are erected and tested : it is 91ft long and 87ft across at the top, the main dimensions being shown in the sketch (Fig. 6) on page 124. The walls of the turbine pit and the adjoining condenser pit are of reinforced concrete up to 5ft thick. Three large machines can be erected simultaneously. To allow the maximum freedom in the erection of turbines of any size above the test pit, the whole of the base of the bed (Fig. 2) is equipped with plates slotted with tee-slots to receive the cast iron stools, 30in square, on which the supporting columns stand. The columns, 26in square at the top, are of a uniform height of 8ft 4in. They support the beams spanning the pit through register blocks designed for packing of variable depth to provide fine adjustment of level (Fig. 3). The beams on which the machines are bolted are in three sections, two of them 17ft long and the third, at the frame end, 11ft long. All sections are 3ft 4in deep and 18in wide. The positions of the beams and supporting columns can be changed to suit the dimensions of the turbine to be erected. At each end of the pit three 10 cwt electric hoists are mounted on 20ft radius arms along which they can be traversed manually ; the arms are pivoted from a common vertical girder. Also, six 50 cwt cranes on 18ft radius jibs are provided.

Steam from the adjacent boiler-house is supplied at 665 lb per square inch, 875 deg. Fah. through 6in bore piping. From each turbine 4ft diameter exhaust pipes (Fig. 2) run into a 4ft 6in diameter main trunking of ribbed construction, leading to the single-pass condenser, which was supplied by Worthington-Simpson, Ltd., to deal with 45,000 lb per hour of exhaust steam from machines under test, at 28in Hg. vacuum. This condenser has a surface area of 4000 square feet and is complete with its own extractor and circulating water pumps driven by G.E.C. motors.

Lubricating oil for the turbines is circulated by duplicate motor-driven pumps through oil coolers, storage tanks and oil cleaning and centrifugal plant. All supply facilities are designed to enable from one to three machines to be run simultaneously or individually at any position on the pit. After assembly turbines are tested at overspeed conditions.

Steam for the new shop is generated by an International Combustion boiler of special design. It is a twin-furnace, oil-fired boiler which is differentially fired to provide steam at any predetermined temperature up to 875 deg. Fah. The capacity of the boiler is 45,000 lb per hour at 665 lb per square inch gauge, and it is complete with its own forced and induced draught fans, and feed heating, including a de-aerator supplied by the Neckar Water Softening Company, Ltd. Provision has been made for an independently fired boost superheater to be provided at a later stage in order to raise the temperature of the steam to 1060 deg. Fah.

Machine Tools.—The new shop is equipped for the planing, boring and drilling of large castings and machining of smaller parts. Rotor discs are machined here, but the fitting of the blades and

Fig. 5—The new heavy turbine shop in the Fraser and Chalmers Engineering Works, Erith, can be seen in the centre foreground of this aerial view, immediately to the right of the boiler house chimneys

the assembling and balancing of the rotors is done in one of the other turbine shops, whence they are delivered to the new shop for building into the machines.

Most of the machine tools are installed in the annexe, but some of the larger units are accommodated in the main shop (Fig. 1). For example, there is a Froriep 26ft vertical boring and turning mill suitable for work on the larger parts, such as turbine exhaust casings. This machine was among those sent from Germany after the war as reparations. The table, made in three sections, will take a total load of 200 tons and is 25ft 9in in diameter, and the maximum height under the tool is 13ft 11½in. The main motor is a 500V d.c. machine of 173 h.p. and the speed range of the mill is from 0·2 to 6·7 r.p.m. The auxiliary motors consist of two of 7½ h.p. for rapid traverse of the slides and two of the same rating for rapid traverse of the rams, one 33½ h.p. motor for raising and lowering the cross rail, a 12½ h.p. motor for mechanical clamping of the rail, and a 1 h.p. oil pump motor; all these auxiliary motors are 415V, a.c. machines.

A Craven 12ft vertical boring and turning mill with 5ft 6in ram traverse is to be installed in the main shop for machining high-pressure steam toolboxes; two small pump motors will be fitted for lubrication.

The main shop also contains a Kitchen and Wade horizontal boring and tapping machine with a 4in spindle, having thirty-six speeds and eighteen rates of feed, driven by a 10 h.p. motor.

In the annexe there are internal and external grinding machines, lathes, horizontal and vertical boring, facing and turning machines, and a slotting machine. The grinding machines are a Churchill model a.c. 48in universal internal grinder, with 24in swing over the table, for grinding valve bodies; and a Churchill "CW" 12in by 72in plain grinder for grinding governor shafts. Both machines have hydraulic table traverse. There are two Swift "V5" 36in centre lathes, which admit, respectively, 10ft 6in and 21ft between centres; eighteen speeds between 4 r.p.m. and 230 r.p.m. are available, together with normal and coarse rates of feed. The machines have 20 h.p. driving motors. In addition, three small Swift lathes with 12½ h.p. motors and eighteen speeds between 9 r.p.m. and 420 r.p.m. are installed for detail work. A large Swift lathe is to be provided for cutting high-pressure turbine shafts from the solid. The length between centres is 18ft and the headstock has been

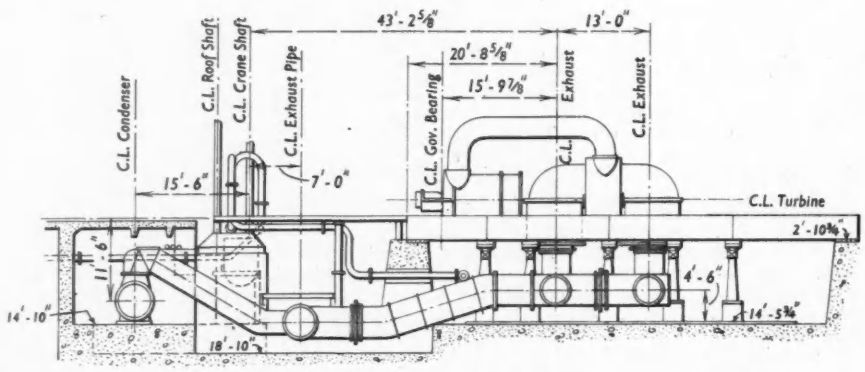


Fig. 6—Diagram of turbine test and erection pit showing arrangement of stools, columns and beams for supporting machines erected for test

casings, and will be arranged to admit 10ft 6in under the tool holder. The main driving motor is of 50 h.p. A 6ft vertical boring and turning mill of Craven manufacture is also provided, and a similar machine in the annexe will be used for taper turning when machining rotor discs before the blades are fitted.

In the main shop there is an Asquith 12ft 6in radial drilling machine, which is employed on drilling bolt holes in all casings and has been adapted to take work of over 10ft 6in under the spindle.

For boring turbine cylinders the shop is also equipped with a Noble and Lund machine (Fig. 4), taking a 12in boring bar. The height from the centre line to the 23ft 9in by 10ft work bed-plate is 9ft, and the distance between steadies 20ft. Sixteen spindle speeds are provided by a drive from a 3 h.p. variable-speed motor through a change-speed gearbox. The main driving motor is of 20 h.p. and auxiliary 7½ h.p. motors are provided for rapid power traverse of the headstock and boring steadies, and rapid adjustment of the outer steady.

Later this year it is proposed to install a 45ft stroke Craven planer for the planing of turbine casings, with measurements of 15ft between uprights and 10ft 6in under the tool. This machine will have two toolboxes on the cross slide and one side toolbox on each upright. Electromagnetic tool lifting will be used to raise the tools from the work on the return stroke, and the table will be driven through spiral gears. The main drive will be from a 120 h.p. variable-speed d.c. motor supplied from a Ward-Leonard set, having a speed range of 350/700 r.p.m. The cutting and return speeds will be 20ft to 120ft per minute in high gear and 12½ft to 75ft per minute in low gear. Both saddles of the machine will be adapted for cross planing and driven by a separate 25 h.p. reversing motor. A 15 h.p. motor will drive the electric feed gear, and the same motor will be used for quick traverse of the raised specially by 7½in for the work on which it is to be employed.

A Richards No. 4 "Electrobore" horizontal boring and facing machine, with traversing spindle and arranged for screw cutting, is installed for work on valve bodies and small parts. The maximum height from the 4ft by 4ft revolving table to the spindle is 38½in.

Keyways in turbine rotor discs are cut on a 16in Ormerod slotting machine with self-acting longitudinal, traverse and circular power feed. Another Craven 6ft vertical boring and turning mill similar to the one in the main shop is installed in the annexe, together with two 10ft Craven machines, driven by 40 h.p. motors, of similar type. Finally the annexe contains three Mitchell double grinders for general maintenance of tools and an Asquith 5ft 9in portable drill.

Electrical Services.—A three-phase supply is brought into the switch room of the new shop from the 2850V works ring main circuit. Two 250kVA external transformers step down the supply to 415V. The low-voltage supply is brought into a six-panel board for distribution throughout the shop. A d.c. supply is obtained from the works rectifiers. Switchgear on all the shop distribution boards is colour coded: green, 415V a.c.; red, 500V d.c.; grey, 250V d.c. A 127kVA power factor correction capacitor assembly is housed in the switchgear room.

Lighting in the main shop is provided by a combination of mercury and fluorescent sources. Three rows of 1kW mercury lamps in high bay fittings are supported on brackets from the roof trusses at 20ft centres longitudinally and with 37ft between the rows at a height of 58ft above floor level.

A row of angle type twin-tube fluorescent fittings with louvres runs round all four walls of the main shop 30ft above the floor. The fittings are mounted end to end except where spacing is necessitated by the structural design. The average service illumination is 20 lumens per square foot, the proportion of fluorescent to mercury sources being designed to produce a pleasing quality of light.

Combined mercury and tungsten fittings are installed in the machine tool annexe; each fitting houses one 400W mercury and one 750W tungsten lamp, with a reflector designed to give similar light distribution from both sources and thus obtain effective colour blending.

Heating is by a hot water system with "Electroflo" electronic control of water temperature, using water heated by steam supplied at 200 lb per square inch pressure from the main boiler plant. The water is pump circulated through nineteen downstream dual-flow heaters with fans for circulation of air. In addition, radiant heating panels are mounted at 13ft level round the shop. Further unit heaters, mounted in pairs above the doors, are arranged to be switched on automatically when the doors are opened in cold weather.

Natural light is admitted both by windows and continuous glazing in the roof. All high-level windows can be motor-operated from remote control push-button stations at floor level; local control push buttons are fitted at window level. Ventilation is provided by roof cowls.

The main contractors for the new building were as follows:—Steelwork, Dorman, Long and Co., Ltd.; foundations and builders' work, Wm. F. Blay, Ltd., London; glazing, Mellowes and Co., Ltd., London; sheeting, Robertson Thain, Ltd., Cheshire; insulation, the British Plaster Board, Ltd., London; doors, Potter Rax, Ltd., London.

Machines Erected at Opening Ceremony.—At the official opening of the new shop, Lord Citrine unveiled a plaque and started up an 11,215 h.p. turbine which was on the bed for adjustment of governing valve and auxiliaries preparatory to being coupled to a 90,000 cubic feet per minute blower for a closed circuit air volume test. The complete turbo-blower is the first of two 90,000 cubic feet per minute sets being supplied for the power station of the new works of Colvilles, Ltd., at Ravenscraig, Motherwell, where the G.E.C. is the main contractor for the power installation. When installed, the Colvilles blower turbines will run at 2310/2700 r.p.m. and operate at 400 lb per square inch gauge, 800 deg. Fah., giving an output from the blower of 90,000 cubic feet per minute of air at 32 lb per square inch gauge.

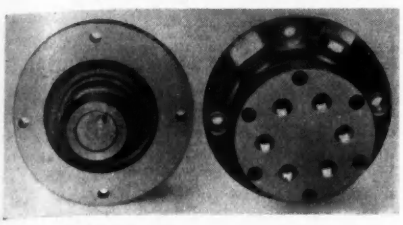
Two turbines for G.E.C. turbo-alternator plant being supplied to C.E.A. power stations were also on the bed. One of these was the sixth 60MW machine for Uskmouth, where the turbines operate with steam conditions of 900 lb per square inch gauge, 900 deg. Fah., and vacuum of 28·9in Hg.

The other turbine on the bed was the fourth of five 30MW, 3000 r.p.m. machines being supplied to the Huncoat generating station of the C.E.A. Steam conditions of the turbine are 600 lb per square inch gauge, 850 deg. Fah., and vacuum 28·6 Hg.

The opening of the new turbine shop was timely, for, as Sir Harry Railing, chairman of The General Electric Company, Ltd., pointed out at a luncheon after the opening ceremony, it was exactly fifty years ago that the first steam turbine was dispatched from the Fraser and Chalmers Engineering Works. It was the first turbine to have been built by the company under licence from Professor Rateau. By that time the company had already been established in London (1890), with a works on the present site at Erith (1891); it had acquired the whole of the issued share capital of the parent firm, the American Fraser and Chalmers company, and it was manufacturing materials handling equipment as well as mining machinery. Sir Harry went on to recall some of the technical advances made by the company: it introduced the vortex design of turbine blade; it led the way in the development of two casing designs for turbines of large output; it developed the first practical form of supervisory control gear, and it evolved what was known as the Bettington pulverised fuel system for firing boilers with low-grade fuels. The company also developed aircraft carrier lifts and in this particular it equipped every aircraft carrier in the Royal Navy, including the "Ark Royal," with its deck edge lift.

Air Starting System for Small Diesel Engines

A NEW compressed air system for starting small two or four-stroke diesel engines, has been introduced by The Hymatic Engineering Company, Ltd., Redditch. The system, which uses automatic, directly operated injector valves, is available for engines having up to eight cylinders and up to 20 b.h.p. per cylinder. This differs

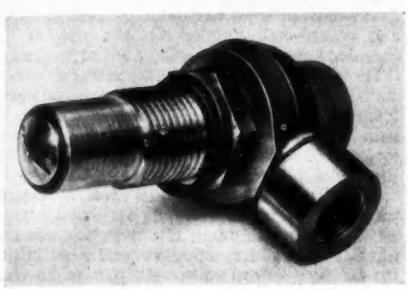


Distributor for a six-cylinder engine

from the equipment produced for starting larger engines which employs pilot-operated injector valves to give the necessary air flow with minimum pipe restriction.

A Mark SH 20/WS two-stage compressor from the company's range of compressors is recommended for the new system and this unit, which is water cooled, can deliver air at 600 lb per square inch.

Air at 450 lb per square inch is fed from an air receiver through a Hymatic Mark S.V.30



Automatic directly operated injector valve

lever-operated stop valve which incorporates a spring action to assist closure and has replaceable rubber rings acting as seals at the valve face and operating shaft. From the valve the air passes to a distributor, an example of which we illustrate, which is driven by either the engine crankshaft or camshaft, and has a rotor consisting of a flat plate with a hole drilled near the periphery. This hole registers in turn with each of the ports leading to the individual cylinders.

When the stop valve is opened the distributor rotor is forced into direct contact with the ports, while at the same time an effective driving shaft seal is made. In this way air is admitted through an injector valve to that cylinder in which the piston is just past top dead centre on the working stroke, and imparts an initial turning moment. Thereafter air is passed into each cylinder in turn until the starting speed is reached. In four-stroke engines the injection period is from 10 deg. to 45 deg. after top dead centre, while in two-stroke engines the period is from 10 deg. to 80 deg. after top dead centre. High-quality cast iron is used for the distributor body and graphited sintered iron for the rotor; thus during starting, when the lapped faces of the distributor are in direct contact, the friction and, hence, the power consumption are reduced to a minimum. With the air isolating valve closed and the engine running normally, the faces are not in positive contact and, therefore, wear is slight. The injector valve, known as Hymatic type IV.5/1, and shown in our illustration, has a body of phosphor bronze and a spindle of E.N.58A high-quality steel, materials which were chosen to eliminate the possibility of electrolytic action at sea. Provision can be made easily in the design of the cylinder head to accommodate the automatic direct-operated injector valve, since it has approximately the same dimensions as a car sparking plug.

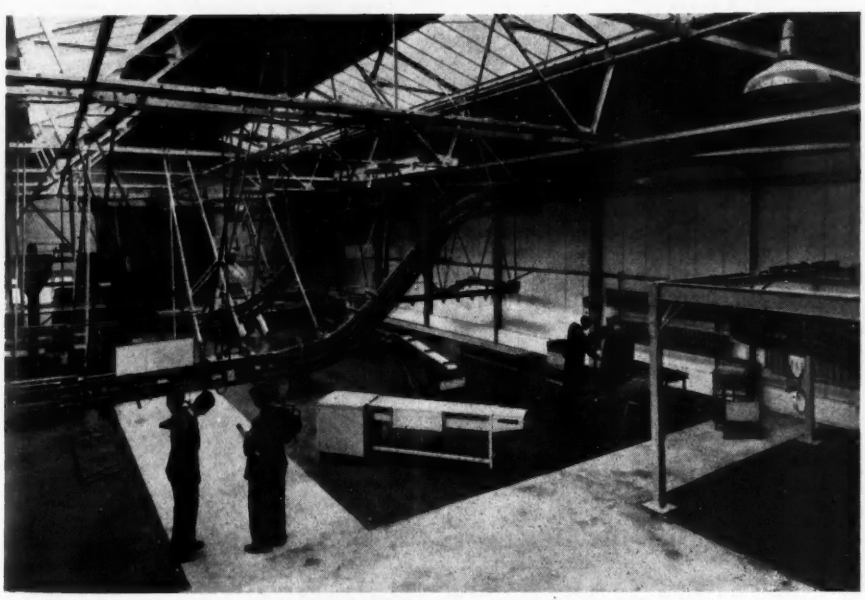
Conveyor Demonstration Centre

WE were recently invited by the materials handling division of Fisher and Ludlow, Ltd., Bordesley Works, Birmingham, 12, to see a centre which the firm has equipped for the demonstration of the materials-handling equipment which it manufactures. The centre is in a new building at the firm's Albion Works at Birmingham and is intended to give facilities for the development and demonstration of materials-handling installations of various kinds. It includes a conference room, drawing-office, a workshop for preparing experimental installations, and demonstration space where seventeen different kinds of conveyor are installed, and may be operated under working conditions.

The equipment to be seen at the centre is, in general, made to the firm's standard system. It includes a chain conveyor for heavy duty; the chain is of 40,000 lb capacity and the circuit installed demonstrates the design of drive, tension, roller bend, sprocket turn, and chain and trollies. The "Flowmaster" conveyor systems to be seen at the centre can be arranged so that trollies can be automatically switched to "dead" tracks or returned to the conveyor line. Any track can be by-passed if it is already occupied to capacity. This installation is the principal one which can be seen in the accompanying illustration. A second lay-out of the "Flowmaster" system demonstrates how trollies can be fed to required positions and then "stored" while an operation is being carried out.

Various belt and roller conveyors are also to be seen at the centre. They include a narrow-belt conveyor for handling thin circular blanks which need to be transferred from one conveyor to another at right angles, and devices such as flexible gravity conveyors and vibratory belt conveyors.

The handling of small-sized solids or powders in tubes is shown with a demonstration circuit of a tubular conveyor. The use of pallets and fork-lift trucks also forms part of the demonstrations, and pallets and storage equipment for many different classes of work may be seen.



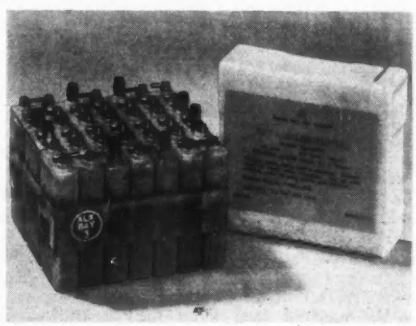
Some of the equipment installed in the conveyor demonstration centre

Lightweight Alkaline Battery for Aircraft

A LIGHTWEIGHT, 24V alkaline battery for emergency duties in high speed aircraft has been developed by Nife Batteries, of Redditch, Worcs., in conjunction with the Ministry of Supply, to provide emergency power for turn and slip indicators and cockpit lighting. It weighs under 3 lb, and its overall dimensions are 4·25in by 4·25in by 3·375in high.

The new battery, which is also available for civil aircraft, is designed to operate without electrolyte leakage under aerobatic conditions at reduced barometric pressures equivalent to altitudes of up to 60,000ft. It is built to withstand stresses of 30*g* in any direction.

As illustrated here, the battery consists of twenty one nickel cadmium "MPO4" cells (each 1·33in by 0·57in by 3·1in high), with a nominal capacity of 0·4Ah. The emergency load amounts to 11W for a minimum of twenty



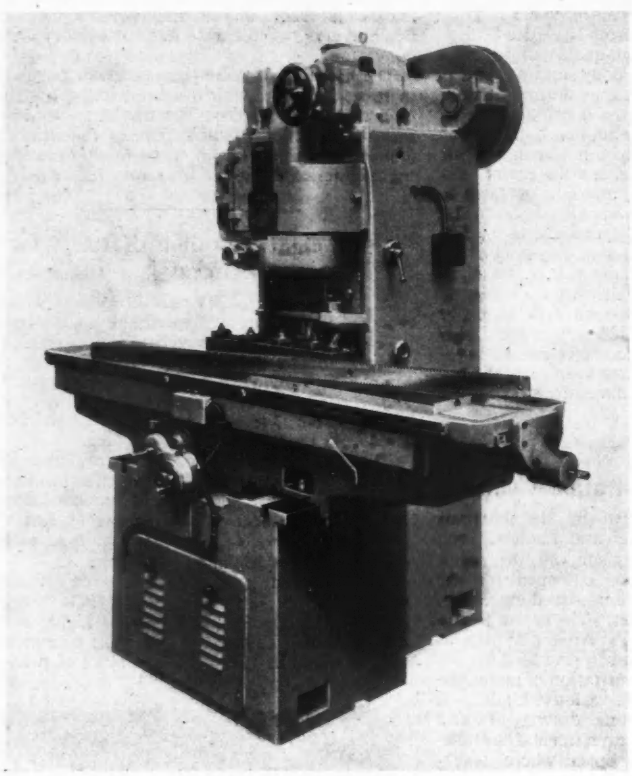
24V alkaline battery to provide emergency power for turn and slip indicators and cockpit lighting in high-speed aircraft

minutes—5W for the turn and slip indicator and 6W for the cockpit lighting. The cells assembled in high impact polystyrene containers, are based on the standard Nife nickel cadmium design with a margin of reserve sufficient to allow a final operating voltage in excess of the stipulated 21V. Increased mechanical strength is achieved by a special method of construction whereby the 21 cells are cemented together in a block (as illustrated) and bound with glass fibre tape impregnated with polyester resin. The terminals are protected by a cover of glass-fibre-reinforced polyester resin with locating grooves for the hold down clamps provided in the aircraft.

MOTOR VEHICLE PRODUCTION.—The monthly statistical review of the Society of Motor Manufacturers and Traders for July, 1955, shows that during the month of May the average weekly output of the industry in this country was 18,280 motor-cars and 6740 commercial vehicles. During the first five months of this year the total production of cars was 374,773 and of motor vehicles 134,142. During the month of May, 33,577 cars, valued at £10·7 million, and 12,924 commercial vehicles, valued at £7·1 million, were exported.

Vertical Rack Generating Machines

We illustrate below a vertical rack generating machine which is made by W. E. Sykes, Ltd., Staines, Middlesex, in two sizes, for cutting racks up to 60in and 72in long, respectively. Work with a maximum face width of 3in can be handled on each of these machines and within a range of approximately 5 D.P. to 64 D.P. Diametral, circular and module pitches can be generated, and either spur or helical teeth up to a maximum angle of 45 deg. The machine is also adaptable for the production of regular or irregular profiles singly, intermittently or continuously along a work blank. Eight cutting speeds from 66 to 662 strokes per minute are available, and the generating feeds are variable through change gears and range from 0·0045in to 0·014in with a 4in P.C.D. cutter.



Rack generator for racks up to 60in long, and 5 D.P.

As can be seen from the illustration, all controls on the machine are conveniently grouped and setting up is simplified by the provision of a dial gauge fixture for truing the work and a large micrometer dial on the front of the infeed shaft, which shows the depth of cut. Adjustable limit switches stop the machine automatically when the required length of table traverse has been completed, and since cutting can be effected in either direction of table traverse, all that is necessary is to set the control to "Reverse," when cutting can be resumed without the necessity of returning the table to its starting point. On the front of the machine table there is a vernier scale that enables the operator to "pitch in" accurately at any required point so that when intermittent racks have to be produced, minimum time is lost in traversing sections that do not have to be cut. These machines operate on the Sykes continuous rotary generating principle. The cutter is mounted on a spindle reciprocated by a crank with a throw which is adjustable to suit the required face width; and a further simple adjustment governs the height of the cutter above the work table. Cutting is effected on the downward stroke, the return stroke relief operating on the cutter head itself, whilst the work table, work and fixture remain steady.

As it reciprocates the cutter slowly rotates in mesh with the work so that cutter and work are exact counterparts both in profile and in accuracy. Racks of any length within the capacity of the machine can be generated with the same cutter provided that the pitch and also the helix and pressure angles are the same. By standardising cutter pitch diametral pitches can be generated without the necessity of altering the change gear ratio. Changeover from one system of pitch measurement to another can be readily effected by means of index change gears. These gears, together with the feed gears, lubricating pump and filter, are reached through a door at the back of the machine. The cutter spindle guide is of hardened Meehanite and its sleeve is provided with adjustable bearing blocks.

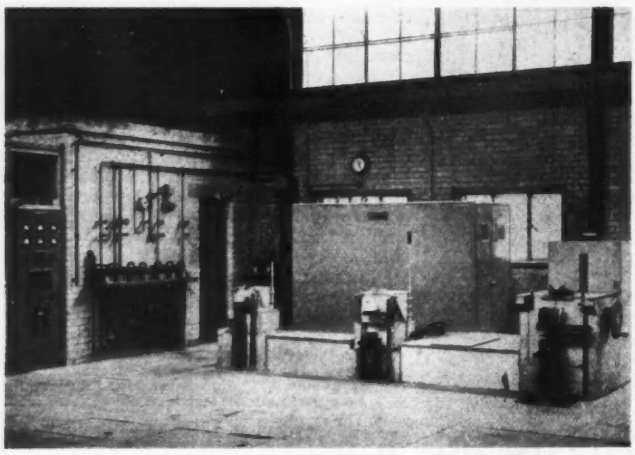
The cutter spindle sleeve, indexing worm-wheel housing and cutter relief block are assembled as a single, rigid unit. The cutter relief operating on the cutter head itself, in a direction parallel to the axis of the indexing worm, entails the movement of a light and rigid unit only, and gives sensitivity at high operating speeds. The slides carrying the cutter head unit are mounted within the rigid box section casting, and the overhang is very small. The vertical column, machine bed and table are massive box-section castings well ribbed to maintain rigidity and the table slides, which are of ample area, are protected by wiper blades.

Steel Research Laboratory Equipment

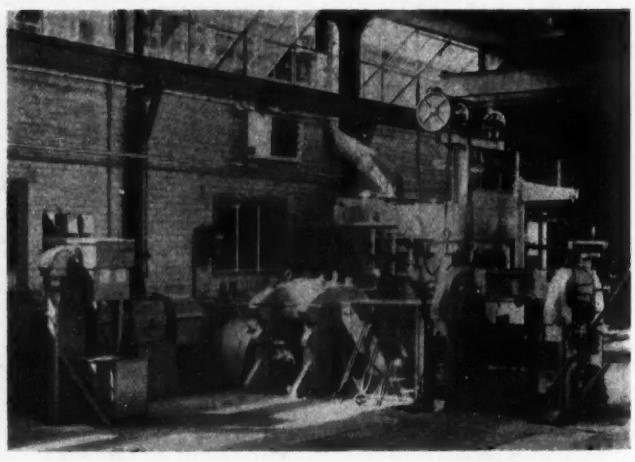
New equipment which has been installed recently at the Swinden Laboratories, Rotherham, of The United Steel Companies, Ltd., includes three electric steelmaking furnaces and an 11in 3-high experimental hot rolling mill. The three high frequency melting furnaces which are illustrated herewith, have been supplied by the Electric Furnace Company Ltd., and are capable of producing experimental ingots of 5 lb, 25 lb and 112 lb weight respectively. Power is supplied to the furnaces from an alternator with an output of 50kW at 9900 c/s single phase, which is driven by a 96 h.p. motor running at 3000 r.p.m. on 415V, three-phase, 50 c/s supply.

The experimental rolling mill, shown in our second illustration, is situated in the same building as, and adjacent to, the furnaces. It was supplied by B. Thornton, Ltd., and is driven by a Metropolitan-Vickers 100 h.p. a.c. motor through a David Brown four-speed gearbox, "Radicon" worm reduction gearing, and pinions. The mill is served by an electric direct-resistance billet heater, which was designed and constructed by the research staff at the Swinden Laboratories, and by a 4ft square hearth "Thermic" gas-fired muffle furnace. It is stated that the mill will be used for rolling ingots from the high frequency furnaces into bars, from which specimens can be made for metallurgical examination and mechanical testing in the development of alloy and special purpose steels. The mill will also serve as a research tool for investigations into the manipulation of steel by rolling, and as a test rig for mill auxiliaries or for special problems arising in the production mills. At present this experimental mill has rolls for reducing ingots 2¾in square to ¾in or 1¼in diameter rounds and various intermediate squares. A further set of rolls will soon be available for rolling 4¼in square ingots to 2¾in square billets, or various flats in thicknesses down to ¼in. The mill is equipped for the measurement of roll separating force, spindle torque, and rolling temperatures.

Driving and Traffic Examiners.—To reduce the waiting period for driving tests and cope with the continued increase in the number of applications, the Ministry of Transport and Civil Aviation estimates that between now and the summer of next year about 190 more driving and traffic examiners will be needed. This would raise the number of examiners available for testing to about 810.



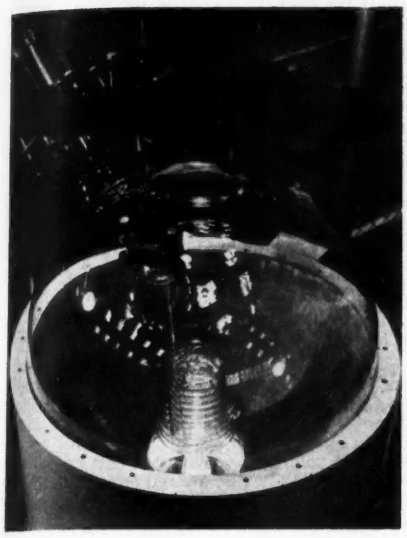
Three high-frequency furnaces for experimental steelmaking. They can produce ingots (from left to right) of 5 lb, 25 lb and 112 lb weight, respectively



11in, three-high experimental hot rolling mill. The gas-fired muffle furnace can be seen immediately behind the mill

Immersion Heat Exchanger

OUR illustration shows a heat exchanger for flasks in which exothermic reactions are to be carried out. Made by Q.V.F., Ltd., of Mill Street, Stone, Staffs, the exchanger has a surface of 5 square feet and is designed for use with flasks of 50, 100 or 200 litres capacity. One of the problems which are met with in chemical plant is the starting and subsequent control of



Heat exchanger for the control of exothermic reactions fitted inside a flask

exothermic reactions. This presents some difficulty with vessels of larger size, which can be heated or cooled only from the outside, since surface increases as the square of the linear dimension, while volume increases as the cube. The solution here adopted consists of placing a substantial heating or cooling surface within the container itself. The exchanger can be used with water or steam up to 50 lb per square inch pressure and with or without an ancillary electric heating mantle.

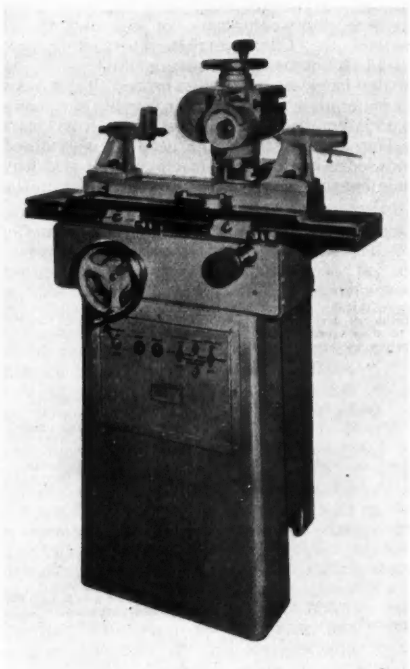
Cutter and Tool Grinder

A NEW cutter and tool grinder now being made by Cincinnati Milling Machines, Ltd., Birmingham, has a capacity of 8in swing and 15in between centres. It has a cartridge grinding wheel spindle mounting with a double row of preloaded anti-friction bearings, packed in grease. This complete spindle assembly can be readily replaced when worn in service, to restore the accuracy of the machine.

A reversible ½ h.p. motor drive, built-in to the wheelhead, provides the desired direction of grinding wheel rotation to suit any particular grinding application. Spindle speeds of 6260 or 3730 r.p.m. are obtainable from the arrangement of the tooth-grip driving belt and sheave. The controls are duplicated to give a choice of operating the machine from the front, right-hand end of the table, or at the rear, right or left-hand side of the wheelhead.

A 360 deg. eccentric wheelhead swivel adds 3in to the conventional 4½in cross range of the machine and facilitates surface grinding operations as well as assuring ample capacity for grinding large-diameter cutters requiring the full 8in swing capacity of the machine. With the use of precision gauge blocks and the swivel table tangent bar taper setting device the operator can position the swivel table quickly and with a high degree of accuracy. This eliminates to a large degree the "cut and try" method when grinding angular cutters and tapered reamers, and is based upon the trigometric function of the tangent of the angle. The operator either multiplies the tangent of one-half the known value of the included angle by 12, or utilises the given value of the taper per foot from the centre-line, as the case may be, to obtain the correct gauge block setting. Replacing either of these values with corresponding precision gauge blocks enables the swivel table to be accurately positioned for grinding the taper.

The double-end, anti-friction spindle of the universal workhead accommodates No. 12 B. and S. (No. 5 Morse optional) taper shanks on one end and No. 50 series National Standard



Cutter and tool grinder with an 8in swing and taking 15in between centres

taper on the other end. Clearance setting dials on both the workhead and left-hand tailstock permit setting for predetermined clearance angles. Electrical controls are built in and neatly recessed in a compartment which can be seen at the front of the machine in the accompanying illustration.

Heavy Duty Strip Forming Machine

PARTICULARS have been received from Heenan and Froude, Ltd., of Worcester, of the recently introduced heavy duty, four-slide strip forming machine, illustrated below. On the standard machine a 21in long die set can be used and this length can be increased up to 31½in on special machines.

The standard machine incorporates mechanism for feeding and straightening stock and can be supplied in alternative forms as follows :—with two rams each of 15 tons capacity, a stock shearing head, and four forming slides ; with one ram of 15 tons capacity, a toggle press unit of 100 tons capacity with stock shearing head, and four forming slides ; or with three 15-ton rams, but without a stock shearing head and left-hand slide.

A five-roll strip straightener is included with adjustable rolls and guide rolls in both planes for strip entry and a quick-release mechanism. The hold on the stock is effected automatically and a maximum length of 14½in of strip can be fed per stroke. An adjustable crank disc is provided which is connected to the feed slide by links and levers, and provision is made for locking the crank pin when the correct length of feed has been set.

The standard ram is of 15 tons maximum capacity and deals with strip material up to 2½in wide by $^{3}/_{32}$in thick. The punch block and die block are kept in correct relation to each other by guide pins, and the complete die set can be easily removed. The die set is 10¾in long on each ram. The shearing head can be adjusted along the bed to suit the position required for the component being manufactured and can be adapted either for a straight shear, or, within certain limits, a shaped end can be cut according to the type of component.

Four forming slides are provided, the end of each slide being fitted with hardened steel rollers mounted on a needle roller assembly. The maximum strokes obtainable are front slide 2¾in, back slide 2¾in and side slides 4in. Each slide is fitted with an adjustable tool block and the tools have two-way micrometer adjustment. Wear strips are provided to take up the play between the slides and slideways.

Cams of hardened steel are split for easy replacement and are adjustable for timing purposes. The centre tool head can be adjusted over a distance of 3in, and the centre tool itself is mounted in a slide enabling a blank to be transferred, if required, by the action of the front tool to a position more convenient to the side slides for the forming action.

The stripper is cam operated through levers and it can be used for a certain amount of vertical forming when required. The stroke of the stripper is adjustable from 1⅛in to 3¼in.

The machine is driven from a 7½ h.p. electric motor and change gears are provided to give camshaft speeds of 40, 52, 65 and 85 r.p.m. A limit switch is provided so that should the machine deliver a short feed the operating sequence is interrupted and the clutch is withdrawn.

ROYAL SANITARY INSTITUTE MUSEUM.—The Royal Sanitary Institute announces that during the period of the reconstruction and modernisation of the Institute's Museum of Health, which, it is anticipated, will take several months, the Museum will be closed to students and members of the public as from August 1, 1955. Further information will be available later about the reopening date, which is expected to be in the spring of 1956.

Four-slide, heavy-duty strip forming machine

Changing Pattern of Maintenance and Repair of the Machinery of the Fleet

By REAR-ADMIRAL JOHN E. COOKE, R.N., M.I.Mech.E.*

No. II—(*Concluded from page 81, July 15th*)

This paper, of which an abstract is printed here, was presented on July 7th at Southampton, during the Summer Meeting of the Institution of Mechanical Engineers. Its purpose is to show the changes which have taken place in the maintenance and repair of the machinery of Her Majesty's ships during the past forty years, the reasons leading up to the changes, and the trend of the future.

In the paper only main and auxiliary machinery are dealt with. The many other items of equipment such as gun mountings, torpedo tubes, aircraft-carrier flight-deck machinery, &c., for which the engineering departments of ships and dockyards are responsible are not touched upon. Neither are the often inter-related items of hull and electrical equipment dealt with. An attempt to do so would make the subject matter too vast.

Shaving Main Gearing in Place.—Attention has been given to applying to main engine reduction gears in service, some post-hobbing process to remove or reduce undulations and small differences of helical angle between wheel and pinions so as to reduce the risk of fatigue failure due to excessive local overloading. The shaving process offered the most promise of being able to do this without having to remove the main wheels from the ship, and equipment for this was tried originally in H.M.S "Myngs" at Portsmouth Dockyard In this case the main wheels were shaved in place in the gearcase, and the pinions in a lathe in the factory. This was successful and it has since been used on main gearing in larger vessels. Some difficulties have now been experienced and the application of the process is receiving further development. In the meantime, gears of large ships coming in hand for modernisation are being checked as opportunity offers by taking undulation records to ascertain those which require treatment.

Deposition of Metals.—The practice of deposition of metals to restore worn or corroded parts had been developed. Metal spraying using mild steel, stainless steel, zinc, aluminium, copper and brass wire is employed freely for building up static parts such as ball races to restore fit on shafts and in housings, and for protective purposes. Its use on dynamic parts is confined to items where, if failure of the deposited metal occurred, the results would not be unduly serious. Examples of this are turbine rotor shafts in way of carbon glands. The general run of dynamic parts are built up by electro-deposition. This is more costly and takes longer than metallising and with current advances in metallising practice the use of the latter is now being considered for dynamic parts such as turbine rotor journals where failure could be disastrous. Electro-deposition is also used to put hard surfaces on working parts and restore this surface when worn. Metal spraying using metallic powders is at present confined to coating parts for protective purposes.

In the post-war years there has been much development of weld deposition to restore worn and corroded propeller shafting up to the largest sizes, and considerable skill has been achieved in avoiding distortion of the shaft and cracking of the deposited metal. Many other items are built up by this process and the now common practice of applying an ultra-hard facing to valve seats is employed. Argon-arc, and carbon-arc welding is used for building up non-ferrous materials. A further method of reclamation used is that of freezing in new parts. This is particularly applicable to submarine engine aluminium pistons in which a fully floating gudgeon-pin works in bosses cast in the piston. Pistons worn at this position are treated by boring out the bosses and freezing in new aluminium bushes of the same alloy.

Machine Tools and Materials.—There have been many advances in machine tools and cutting tools during and since the war, and advantage of this has been taken, as money will allow, to ensure that the workshops are equipped to deal with present and future equipment and materials. All belt-driven machine tools are being eliminated, replacements being individually motor driven. Cutting speeds are increased. Rigidity and accuracy are improved. The process is continuous: some idea of what has happened in dockyard workshops during the past forty years is given in an appendix [not reproduced here] showing the changes which have occurred in the machine tool equipment of the factory at Portsmouth. Change in materials made to meet design requirements and reduce maintenance and repair is likewise a continuous process. Table I lists the materials in common use in warship machinery in 1955 compared with those in use forty years earlier, and illustrates the need for specialised knowledge and modern machine tools and why maintenance, in the sense of the definition at the beginning of this paper, is not so straightforward as it was during the 1914–18 war.

TABLE I—*Materials in Common Use in Repair of Warship Machinery*

1915	1955
	Ferrous
Wrought iron	
Machinery steel 25–28 tons per square inch	Machinery steels offering 25–55 tons per square inch
Carbon case-hardening steel	EN.32 for case hardening
	Numerous alloy steels to B.S. 970, including:
	EN.16, Manganese, molybdenum
	EN.18, 1 per cent chromium
	EN.20, 1 per cent chromium, molybdenum
	EN.22, 3½ per cent nickel
	EN.23, 3 per cent nickel, chromium
	EN.110, low-nickel, chromium, molybdenum
	EN.53, silicon, chromium
	Case hardening
	EN.39B, 4¼ per cent nickel, chromium, molybdenum
	EN.351, ¾ per cent nickel, chromium
	Rust and acid resisting
	EN.56, 13 per cent chromium
	EN.57, 18 per cent chromium, nickel
	EN.58, austenitic chromium, nickel
Cast iron	Cast iron
	Meehanite
	Non-Ferrous
Brass	Brass
Naval brass	Naval brass
	High-tension brass
Gunmetal	Gunmetal
Phosphor bronze	Phosphor bronze
Manganese bronze	Manganese bronze
	Aluminium bronze
	Nickel-aluminium bronze
	Leaded bronze
	Aluminium brass
	Aluminium copper
	Cupro-nickel
	Monel metal
Copper	Copper
Zinc	Copper-nickel-iron
	Aluminium
	Aluminium alloys
	Magnesium alloys
Admiralty white metal	Admiralty white metal
	Admiralty underwater white metal
	Hoyts metal
	Babbits metal
	Rubber

Steam Testing.—Functional steam testing of auxiliary machinery has been introduced in the dockyards such that every auxiliary after refit or overhaul is proven under steam, except for full loading, which is impracticable, before it leaves the factory for replacement in the ship. This is an invaluable advance as it enables errors in overhaul and such functions as governor speed, trip speed, running clearances, &c., to be determined under much better conditions than are obtainable in a ship and prior to fitting in the ship when very much more work is involved should rectification be necessary. An incident at Portsmouth Dockyard just prior to the completion of the steam test plant occurred in one of H.M. ships in which two identical turbo-driven auxiliaries, after refit in the factory, vibrated heavily during post refit trials of the ship. The turbines were opened and each rotor was found to have still attached to it a lathe carrier used during the grinding operation. The carrier was sunk into a part of the rotor not readily visible and had escaped inspection. That there was no delay in that ship passing into service was entirely due to most abnormal efforts by the factory staff of the section in which the omission occurred. It will, however, be readily appreciated that this could have been very serious, and that it would have been avoided had the auxiliaries in question been steam tested before leaving the factory.

Dockyard Practices.—Large tailshafts are awkward things to get in and out of the stern of a ship. They may weigh up to 20 tons and be up to 90ft long. Added to which, when they are rubber covered except in way of bearing surfaces, extreme care is necessary to avoid damage to the fragile coating when threading through the A-frame and stern tube. Heavy lifting tackle rigged to the hull and much time and labour used to be necessary for this operation. A practice has now been developed in which two bogies running on rails are placed in the bottom of the dock in line with, and immediately under, the axis of the shaft, one just aft of the stern tube and the other just aft of the A-frame. These bogies each carry V-block supports, easily adjustable for height by the screw jack principle, which take the weight of the shaft and lift it clear of the stern tube and A-frame. The bogies are towed aft by a wire attached to a winch, the vertically adjustable V-blocks being continuously lowered by hand at a rate to suit the change of height of the shaft in relation to the horizontal dock bottom, as the shaft moves aft. When clear of the stern of the ship the shaft is lifted from the bogies by a dockside crane and landed in the usual manner. Should there be insufficient length of dock clear of the stern of the ship for this, the shaft is rolled out of the V-blocks on to wooden baulks as soon as it is clear of the A-frame, and transferred by rolling to the side of the dock where a crane can plumb. Shafts are replaced in the same manner. The whole operation of removal or replacement from shaft in position in ship to landing on the dockside can be carried out in five to six hours, or a little longer if rolling is necessary. This equipment has been used to withdraw and replace the shafts in H.M.S. "Victorious," now undergoing reconstruction at Portsmouth Dockyard.

Advance in the repair facilities of the dockyard to meet the future trend of machinery coming into service to be refitted continues. Further reference is made to this. The more complicated machinery already in common service with the Fleet is taking an increased labour effort for its repair. An analysis made at Portsmouth Dockyard in 1951 showed that, compared with 1929, it takes approximately 60 per cent more man-hours to refit such items as feed pumps, distiller pumps, safety valves, &c. The human element undoubtedly enters into this, but in the main it is a fair comparison. The effort required by more advanced units has yet to be assessed in practice.

The Influence of New Design on Maintenance and Repair Policy

In the world of design, advance did not stop during the 1939–45 war. The ever-present spur for more power in less space and for less weight, coupled with increased endurance and decreased maintenance, postulated higher steam conditions, higher rotational speeds, standardisation of equipment, and true interchangeability of parts. Such an advance entailed a change of maintenance policy and the need for shop testing of new design machinery before installation in ships, coupled with the introduction of standard designs and common auxiliaries as far as possible. Towards the end of the war the "Daring" class design emerged having as a basis steam conditions of 650 lb per square inch pressure, 850 deg. Fah. temperature and employing several different types of turbine, gearing, boiler and auxiliaries, and in which, as far as was then possible, there should be dimensional accuracy of parts and an adequate stock of spare parts and assemblies so that maintenance and repair by replacement could be practised. Standardisation was to come later. By the time that building had started shop testing was made possible by the creation of Parsons and Marine Engineering Turbine Research and Development Association (Pametrada), in which the Admiralty has an interest. All the teething troubles of the several designs of machinery were overcome under ideal conditions ashore, resulting in a very successful class of vessel going directly into service and creating a most favourable impression. The full impact of the change in maintenance and repair of this type of machinery has yet to be felt. Many new materials have been employed and new techniques have to be learnt. The dockyards are being equipped to meet this need. Our old faithful, but now insensitive, balancing

* Engineer Manager at Portsmouth Dockyard.

machines are being replaced by a range of machines covering all high-speed rotating parts in the new designs from small turbo-auxiliaries up to main engine rotors, and having the increased sensitivity necessary for this work. Spot welding machines are being installed for repair of the casings of the high air pressure boilers employed. Heat-treatment furnaces are being provided to deal satisfactorily with the alloy-steel steam piping used. The techniques of maintenance and repair of double-reduction locked-train gearing, welded alloy steam pipes, high air pressure boiler casings, new combustion equipment, high-duty valves, &c., are being studied and mastered by dockyard personnel.

The advance continues in the "Whitby" and "Blackwood" class frigates, in which standardisation is being introduced and all machinery is being made to accurate dimensional tolerances by the acceptance by the builders of responsibility for full delegated dimensional inspection. These advances will in their turn entail further changes in maintenance and in the machinery repair policy and equipment in the dockyards or elsewhere. Repair by replacement will influence maintenance, and it is envisaged that overhaul and repair of auxiliaries will follow that already in use for internal combustion engines. Auxiliaries will be stripped, gauged, replace parts of original dimensions drawn from stock as necessary, rebuilt in a "clean" shop and steam tested before return to the ship, or to store to replace a complete new or fully overhauled auxiliary which may have been fitted in the ship from which the original was taken. This does not mean that the machinery repair shops of the dockyard will cease to become jobbing shops. There are still many ships in service and likely to remain in service for years to come for which repair by "jobbing" must continue. In addition, there are many large items, shafting, propellers, heavy diesel and other reciprocating work which will still require the facilities at present provided. The new policy will thus affect but a small part of the dockyard workshops for many years to come, primarily the turbine-driven auxiliary section, and such new sections may not be sited in the factory or dockyard. The need for centralisation of that type of work, and its ability to be dispersed from enemy target areas, give rise to consideration of an establishment remote from the dockyards at which, in addition to restoration to the "as new" condition, reclamation of worn or defective parts will also be practised. Such matters are receiving active attention.

A further advance lies in the employment of gas turbines as main machinery of small vessels and for certain special-duty auxiliaries. An Admiralty test house for gas turbines, constructed at the National Gas Turbine Establishment was opened by Admiral Sir Michael Denny, K.C.B., C.B.E., D.S.O., then Third Sea Lord and Controller, in November, 1952. Maintenance and repair of this type of machinery introduces new problems, particularly in materials, and the salt-laden atmosphere in which they operate, but these are common, except for the marine aspect, with those being met and dealt with in the Naval Aircraft Repair Yards. Many maintenance problems are eliminated in the very intensive running in the proving stage at the Admiralty Test House and makers' works, and the problems peculiar to marine use are now being solved in prototype sea-going craft.

Future Maintenance Policy in the Fleet

In the ships of the Fleet in the past few years there has been consciousness of the need for planned preventive maintenance in which servicing or maintenance operations are carried out at set periods determined by analysis and experience, and for the maintenance load to be clearly and fully assessed with the exception of unforeseen breakdown, the likelihood of which is much reduced by a fully implemented repair and maintenance routine. These needs, and the need to integrate maintenance and rest periods with operations and determine long-term availability factors, became more apparent and were applied as far as possible during the latter stages of the Korean War as determined by experience hardly learnt, and in individual ships by far-thinking engineer officers.

Recently, machinery has been set up for the preparation of preventive maintenance schedules for various classes of ships. This has been applied in the first case to new construction ships very recently in service and those now building and shortly to come into service. In the machinery field every item is broken down into its component parts, its liability to wear or derangement is studied, the frequency of examination or maintenance required is assessed, and the nature of the examination and details of the maintenance to be carried out are stipulated. Each item is studied by means of detailed drawings, by examination and discussion at the maker's works and by examination on installation in the ship. From these assessments and estimates first maintenance schedules are being constructed.

To enable the first maintenance schedules to be corrected by practical experience, and to co-ordinate, analyse and eliminate as far as possible the material failures and maintenance difficulties experienced in each ship of a class, which may be divided amongst several administrative authorities in different parts of the world without direct connection between them, Class Authorities have been set up to function under the direction of the Commanders-in-Chief or Flag Officers at each Home Command. For this purpose certain classes of ships are allocated to each Commander-in-Chief or Flag Officer concerned. The Class Authorities will deal with the hull and the electrical equipment as well as the mechanical equipment, estimate the man-power necessary to carry out the examinations and maintenance required by the maintenance schedules in terms of skilled and unskilled man-hours and, in conjunction with Admiralty and Dockyard Officers, assess ship, base, and dockyard components of maintenance and man-power required. They will, by means of a reporting system, maintain a record of the material state of every ship and its more important equipment in the classes for which they are responsible, make recommendations for amendments to maintenance schedules, develop more efficient maintenance practices, and feed back co-ordinated experience to the design departments. They will advise Admiralty and Fleet Authorities, as they may require, on material state and optimum usage-maintenance cycles. This will be the Fleet component of material maintenance. In the Admiralty, the basis of complementing is being examined to take account of the manpower necessary to meet the Class Authority estimates of manpower required to carry out the maintenance schedules and equate these to the many conflicting factors of man-power available, accommodation in ships, and extent of base and dockyard effort to undertake maintenance work.

Repair Policy in the Dockyards

The dockyard component of material maintenance and repair of the ships of the Fleet has been reassessed by the Director of Dockyards and a procedure complementary to the Fleet component of material maintenance has been framed. At present ships are refitted by making good the defects submitted on a defect list by ship's officers prior to the refit, plus those defects discovered during the course of the refit by ship and dockyard officers. The refit is of limited duration and is intended to restore the material state of the ship until the next periodic refit of similar nature is due. It is now under consideration to bring into being for each class of ship a refit cycle, of length according to class of ship and duties, consisting of an extended refit followed by two or more short refits, all of which are interrelated and for which standard class defect lists are being prepared. The extended refits, particularly in the first instance, are, as opposed to rationed refits, designed to ensure that at the end of the refit the material state of the ship is such that planned preventive maintenance can be employed effectively, and the interrelated two or more short refits in each complete cycle are intended to be of a nature and extent to enable planned preventive maintenance to be continued, so that breakdown maintenance is at all times reduced to that which cannot in any way be foreseen or guarded against, and to ensure that the material state of the ship is kept at a high standard throughout the cycle. Standard class defect lists are being prepared jointly by the department of the director of dockyards and dockyard officers based on previous experience, and the to-be-agreed dockyard component of maintenance; they may be subsequently amended by the to-be-acquired knowledge and experience of the newly instituted Class Authorities. To these will be added items initiated by ships' staff not covered by the standard class lists and items disclosed by dockyard officers as a result of a planned survey of the ship. The first extended refits are being carried out this year (1955). They will be of an exploratory nature, particularly in regard to the time found to be needed, but they provide the start to a revised conception of refitting the ships of the Fleet.

Conclusions

The foregoing analysis of the past forty years must of necessity be of greater brevity than the subject warrants, but it is suggested that the pattern is clear and that, in general, changes in maintenance and repair of the machinery of the Fleet consequent upon advances in design and additions in equipment have followed a curve of fairly constant, but gentle, slope with a slow falling behind in the ability properly to maintain, until the stage is reached during and after the 1939–45 war, when advances in design postulated freedom from restriction by current maintenance practices, and both maintenance and methods of repair have changed more quickly. There is an increase in the slope of the curve in the past few years and a period of rapid change and sharp slope has now begun. Preventive maintenance and repair by replacement have entered the field of high-powered warship machinery. Their full impact on maintenance and repair of the machinery of the Fleet has yet to be experienced, but preparations are being made to meet the impact.

It has become recognised that the maintenance load is built into the ship when it is designed, that it may be increased during the life of the ship, that it must always be fully met and that the assessment of complements must bear some relation to it. Usage-maintenance-repair equations are being established and concerted Admiralty, Fleet and dockyard action is being taken to ensure the constant aim—the highest possible availability and a full "reservoir of serviceability."

The paper is read by permission of the Admiralty. The opinions expressed are personal to the author.

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Institution of Electrical Engineers

The president of the Institution of Electrical Engineers for the 1955–56 session will be Sir George H. Nelson, Bt. The two vacancies for vice-presidents will be filled by Mr. T. E. Goldup, C.B.E., and Sir Hamish D. MacLaren, K.B.E., C.B. The Rt. Hon. The Viscount Falmouth will serve as honorary treasurer. There are four new ordinary members of council, Professor H. E. M. Barlow, Mr. C. M. Cock, Professor J. Greig, and Mr. H. H. Mullens; and there are two new associate members, Mr. D. McDonald and Mr. D. B. Welbourn. The vacancy for a companion will be filled by Mr. G. L. Wates, J.P. The council has co-opted Mr. C. T. Melling, C.B.E., to fill the vacancy created by Sir Hamish D. MacLaren as vice-president before the completion of his term of office as an ordinary member of council.

Hungry Horse Dam in Montana

BY OUR AMERICAN EDITOR

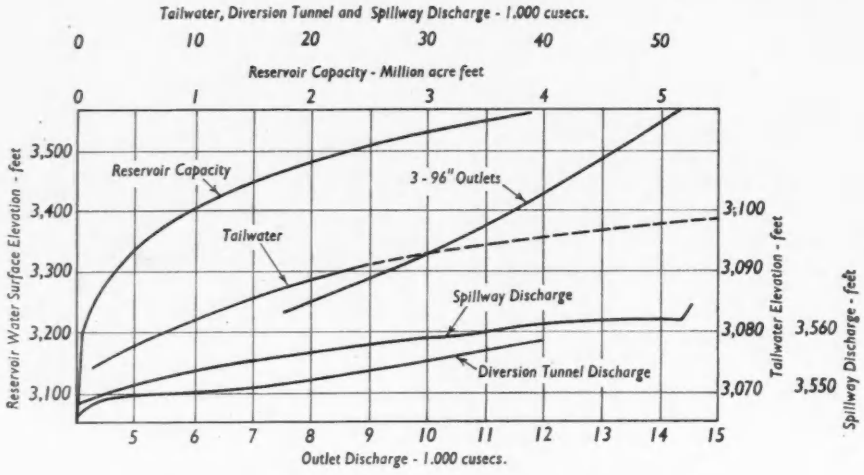
No. II—(*Concluded from page 96, July 15th*)

The Hungry Horse dam and power station of the U.S. Bureau of Reclamation have now been in full operation for over a year. The Hungry Horse project is a combined power generation and flood control scheme within the Columbia River system and is situated in north-western Montana. The dam is a concrete arch gravity structure, 2115ft long at the crest and 564ft high, and the power station has a total generating capacity of 285MW.

THE shaft-and-tunnel spillway, which is commonly known in America as a "morning-glory" structure, is the most interesting hydraulic feature of the Hungry Horse scheme. Overflow water from the reservoir plunges over the crest of the spillway near the right end of the dam and drops about 480ft, discharging through the spillway outlet structure 550ft downstream from the power station. The entire tunnel is lined with concrete and is capable of passing a flow of 50,000 cusecs. The excavation of the 1100ft long tunnel required the removal of about 30,000 cubic yards of rock. The major portion of the spillway tunnel has a circular section which varies from 24ft 6in in diameter to about 35ft in diameter. Then, in order to make use of a portion of the tunnel used for the diversion of the river during the construction of the dam, the circular section connects to the horseshoe-shaped section of the diversion tunnel.

The circular spillway crest, which was illustrated last week, is controlled by a ring gate having a centre line diameter of 64ft and a maximum lift of 12ft. Previously, a similar ring gate has provided successful control for the spillway of the Owyhee dam in Oregon of the Bureau of Reclamation. The top of the gate is at the normal high reservoir water surface when in the raised position. This gate is a closed, watertight, annular ring which is raised by buoyant force. The gate movement is manually controlled by variation of the water level in the gate chamber. The gate is held in alignment by sets of double pinions which engage bevelled racks anchored to the concrete walls of the gate chamber. Drains having flexible joints are attached to the gate bottom to provide interior drainage of the gate if needed. The inner and outer circumferences of the gate are sealed by combination rubber and metal seals between the gate and the crest structure. A system of air nozzles supplied by a compressor is provided around the structure to prevent any ice forming.

When the ring gate is in the lowered position, the spillway discharge varies from free flow at low heads to orifice flow at higher heads as shown in the curves reproduced above. The 37ft diameter orifice situated at the top of the upper tunnel elbow limits the maximum discharge to a head of 45ft. The shape of the top of the gate and the interior of the concrete crest structure was determined from the shape of the under nappe at the maximum discharge, as determined by hydraulic model studies. Smaller discharges and discharges with the gate raised, spring free from this surface shape and require aeration under the nappe. This aeration is provided by air vents under the lip of the gate, and by a concrete air duct which enters the top of the upper elbow. This duct also supplies air to the shaft and tunnel. The choice of an inclined shaft instead of a vertical shaft was based on comparative economic studies. The shaft and tunnel were designed to flow partially full at maximum discharge with aeration provided from the downstream portal to the upper elbow. The shaft was tapered uniformly in diameter from 34·79ft at the bottom of the upper elbow to 24·50ft at the top of the lower elbow. The added cost of moulds for a tapered shaft, as compared with that for a shaft of uniform diameter, was more than offset by savings in the quantity of excavation and volume of concrete lining. Hydraulic model tests showed that an elbow of 120ft radius gave suitable operating conditions. The spillway outlet structure, downstream from the portal, maintains the 36ft width of the tunnel. The floor is raised 13ft 6in by a long-radius curve and forms a vertical deflector which raises the high velocity jet above the tailwater level and allows the jet to enter the river a safe distance from the structure.



Tailwater, capacity and discharge curves of Hungry Horse dam and reservoir

Outlet Structure

Three 96in diameter outlet pipes were provided to regulate more closely the flow of water to meet downstream requirements than would be possible through the spillway and turbine discharges. In addition, they provide a means for rapidly lowering the reservoir in the face of an impending flood. The outlet pipes extend radially through the dam to a valve house situated on the right bank of the river channel about 200ft downstream from the power station. Discharge through the outlet pipes is controlled by hollow jet valves in the valve house and ring-follower gates situated in the foundation of the power plant. A bulkhead gate is also provided for emergency or maintenance work and can be lowered over the upstream end of the outlet pipes by a 150-ton gantry crane situated on the crest of the dam. The maximum capacity of the three pipes is 14,400 cusecs with the reservoir surface at elevation 3560ft.

Power Station

The power station is situated at the toe of the dam and accommodates four main generating sets, illustrated on page 132. Each unit consists of a 75MVA generator driven by a 105,000 h.p. turbine. Four penstocks of 13ft 6in diameter run radially through the dam and enter the scroll cases of the turbines with a diameter of 11ft 9in. Each penstock is about 450ft long and is embedded in the dam except for a short exposed section in the power station, as illustrated opposite. The penstock intakes are protected by a trashrack structure. The penstocks were designed for a total head of 570ft, including static and water hammer heads, under normal operating conditions, and for a total head of 671ft under emergency conditions with a 4 second closing. A design stress of 15,000 lb per square inch was used for the head under normal operating conditions, and of 20,000 lb per square inch under emergency conditions. As all longitudinal joints of the penstocks were radiographed, a joint efficiency of 100 per cent was used in computing the required plate thicknesses, which vary from $\frac{9}{16}$in at the upstream end to $1\frac{5}{16}$in at the downstream end. As the size of the penstocks exceeded transport limitations, it was necessary to fabricate the pipe in a field near the dam. About 1400 tons of steel were required for the fabrication of the four penstocks. The stiffener rings were made from the same steel as the pipe shell. The rings were welded to the shell with continuous small fillet welds, and their ends were butt-welded to form continuous rings as illustrated opposite

Four fixed-wheel gates are provided for emergency and service closure of the four penstocks. These 13·5ft by 18·93ft gates are of structural steel, riveted and bolted. They are mounted on the face of the dam and are operated by hydraulic hoists. Rubber double-wing, solid-bulb seals are mounted on all four gate edges and engage stainless steel seats on the embedded structural steel frames. Corrosion-resistant steel tracks for wheel travel are mounted on the same frames. The maximum design hydraulic pressure on each gate is 126 lb per square inch, and the gate travel is 22ft 9in. The first 21ft 9in of gate closing is effected in $1\frac{1}{4}$ minutes, the last foot in 4 minutes, making a total closing time $5\frac{1}{4}$ minutes. To open the gate requires about 12 minutes.

River Diversion

The river diversion at the dam site required the construction of a 36ft diameter horseshoe-shaped tunnel about 1050ft long through the right abutment. The actual diversion and care of the river during construction of the dam was the responsibility of the general contractor, who constructed cofferdams upstream and downstream from the dam site and diverted the water through the diversion tunnel. Under the contractor's original plan flood flows in excess of 12,500 cusecs would flood the construction area and cause some delay in the construction programme. During 1949 the construction programme was accelerated, the diversion plan was revised, and the upstream cofferdam was raised to permit flood flows up to 40,000 cusecs to pass through the diversion tunnel. By the end of the 1950 concreting season the dam was high enough for there to be no further danger of overtopping by flood flows. At the rate of concrete placement in 1951 the dam was completed to about elevation 3400ft and was able to store any water coming down the river in excess of the capacity of the river outlets. The diversion tunnel was closed by placing the concrete tunnel plug during the 1951–52 winter season, after which storage began in the reservoir.

Construction of Dam

Construction on the Hungry Horse scheme commenced on September 26, 1946, when work was started on the upper access road to the dam

site. The first construction activity at the dam site itself was the above-mentioned work on the diversion tunnel during the 1947–48 winter season. The first work on the dam and power station occurred in June, 1948, when the foundation excavation was started. The first concrete was placed in September, 1949, and 50,000 cubic yards of concrete were placed before cold weather stopped placement in November. Concreting was resumed in March, 1950, and 950,000 cubic yards were placed that year. At the end of 1951 2,401,000 cubic yards were in place, and the last concrete in the dam was placed on October 4, 1952, one year ahead of schedule. The first generator in the power plant went into service in October, 1952, and the entire project was completed in 1954.

The excavation of the "morning-glory" spillway tunnel, which was included in the prime contract for the construction of the dam and power station, was sub-contracted to the Boyles Brothers Drilling Company, of Salt Lake City, Utah. Because of experience gained from similar smaller projects, the sub-contractor departed from conventional methods in excavating the tunnel and utilised a so-called "long-hole" procedure. The initial step of this procedure was the driving of a 9ft by 11ft high pilot bore from the junction of the spillway tunnel with the diversion tunnel (which had already been excavated) to the top of the inclined shaft of the spillway, a distance of about 355ft. Drilling was done with "drifters" and "stopers" installed on a jumbo. From the bottom of the inclined shaft to the spillway inlet on top, a distance of 550ft, the pilot bore was changed in dimension to an 11ft wide by a 5ft 6in high bore and timbered so as to permit the simultaneous passage of muck coming down the bore and men and materials going up. The angle of the inclined shaft was sufficiently steep, so that, after shooting, all loose material fell to the bottom of the inclined portion. From this point the material was moved by bucket through a distance of approximately 200ft to a truck loader. A 75 h.p. double-drum hoist was used to drag the loaded bucket from the pilot bore up a steel ramp and to dump the tunnel muck into trucks standing under an opening in the ramp.

When the pilot bore had progressed sufficiently, circular ring slots were drilled out to the full cross-section of the tunnel. These slots, approximately 18ft wide, were cut at right angles to the axis of the tunnel at approximately 110ft intervals along the pilot bore. Diamond drills were then set up in these slots and the rock drilled around the designed perimeter of the tunnel, with the holes running approximately parallel to the tunnel centre line. After the pattern was drilled completely between any two ring slots, the holes were loaded with 60 per cent dynamite. Because the holes were so deep, "Primacord" was inserted to the full depth to ensure complete detonation. Generally the holes were shot in a series of three or four, those closest to the pilot bore being blasted first and the remaining ones being detonated progressively outward. By this method the rock was always relieved toward the pilot bore, which prevented overbreak. A portable ventilation duct removed foul air trapped in the ring slots.

This "long-hole" method of excavation gave excellent results in the spillway tunnel. There was a minimum of overbreak around the perimeter, and in many instances the outside edge of the original diamond drill hole remained clearly visible on the wall of the tunnel. The condition of the remaining rock was good, as indicated by its sound and comparatively smooth surface. Drilling and shooting were accomplished with the minimum number of machine settings—only eight ring slots were excavated for the total tunnel length of approximately 900ft.

The excavation of the left abutment was accomplished by conventional breast and down-hole rounds. As the rock bedding planes paralleled the foundation the cleavage plane of the rock could be controlled in drilling and blasting. However, some additional excavation was required for the removal of thin unstable planes, separated by a decomposed rock and clay, to ensure a sound foundation. In certain areas of the abutment it was deemed advisable to stabilise the overlying rock slabs and faults rather than to excavate them. On the right abutment the contractor was faced with a difficult excavation task because of the relatively steep slope of the natural terrain, and the close spacing of the right-angle joint planes in the rock. These conditions hindered access to the work and the placing of excavation equipment, and made necessary some vertical cuts of 60ft to 70ft. To expedite the excavation schedule the general contractor sub-contracted the excavation of certain areas of the right abutment to the Boyles Brothers Drilling Company, which had just completed the excavation of the spillway tunnel as previously described. The same diamond drill equipment and methods were used for excavating the abutment. By the end of July, 1950, excavation was virtually completed; 983,000 cubic yards of rock and 73,000 cubic yards of common earth had been excavated.

The first concrete in the Hungry Horse dam was placed on September 7, 1949, and placing was continued until November 15th of that year. Cold weather in the spring of 1950, accompanied by snow and ice, prevented resumption of major concrete placement activities until early April and hampered them for several weeks thereafter. By July, however, the contractor had reached a placement schedule of about 5000 cubic yards per day.

Suitable water for the concrete in the Hungry Horse dam was obtained from a mountain stream, and a number of suitable gravel deposits were found in the immediate vicinity. The main aggregate deposit was a 110-acre area 5 miles downstream from the dam site. Pit-run aggregate was excavated by a 10 cubic yards walking dragline, loaded into 22 cubic yards bottom-dump semi-trailers drawn by tractors, and hauled 4½ miles to the processing plant. There the pit-run material was conveyed by belt from the receiving hopper to the primary screen, where oversize rocks were passed to jaw crushers and returned to the belt conveyor. The belt conveyor ran adjacent to a raw aggregate stockpile 800ft in length. The maximum estimated capacity of the stockpile was 400,000 tons.

Another conveyor belt running through a recovery tunnel under the raw aggregate stockpile carried the material into the main screening

Scroll case of turbine and exposed section of penstock

Installation of 13ft 6in diameter turbine penstocks

plant for complete processing. Here the aggregate was sized, washed and, if necessary, crushed to increase the quantity of the smaller sizes. The resulting aggregates were carried from the screening plant by conveyor belts illustrated herewith and stockpiled by size over the recovery tunnels.

Two recovery tunnels were required because of the necessity for varying the blend of coarse, medium and fine sand. The desired proportions of each grade of sand were removed from the stockpiles situated over the short recovery tunnel and transferred to the blended sand stockpile situated over the main recovery tunnel. The aggregates were moved out of the main stockpiles to storage hoppers over the mixing plant by conveyor belt. A final screening of the aggregate occurred above the storage hoppers. The aggregate plant had a capacity of 630 tons per hour, or sufficient for about 7000 cubic yards of concrete per twenty-hour day.

The mixing plant was situated high up on the right abutment, as illustrated last week. Besides the final screening assembly, storage hoppers and automatic batchers, it had a mixing deck holding five 4 cubic yards mixers spaced in a circle and charged through the front end by a central rotating hopper. Four mixers discharged into one conical hopper, and the fifth mixer, used for special mixes, discharged into an adjacent hopper. Both hoppers were arranged to discharge through air-controlled gates into railway transfer wagons. Both cement and pozzolanic fly ash were delivered by rail to a siding 6½ miles by road from the dam. Here the railway wagons were unloaded into bins beneath the track of an elevated and covered siding. The bins discharged by bottom-hopper gates into weathertight, metal semi-trailers of 880 cubic feet capacity, which were pulled by tractors. The pozzolan and cement trailers discharged into covered receiving hoppers from which the material was transferred by belt conveyor to storage silos situated above the mixing plant. The mixing plant produced about 8000 cubic yards of concrete in a twenty-hour day.

The foundation surfaces of the dam were cleaned free of loose or semi-detached fragments, mud, debris, oil, or standing water immediately before the placing of fresh concrete. This cleaning was accomplished by whatever method was appropriate to the terrain and included the use of equipment ranging from draglines to brooms. Final cleaning was accomplished by wet sandblasting and the application of high-velocity air-water jets. The horizontal surfaces of construction joints were cleaned of all laitance, loose or defective concrete, and other material before receiving fresh concrete. Cooling pipe and other items to be embedded in each new lift were installed and the wet sandblasting was started. Free material and debris were then flushed from the surface. The concrete placement system used consisted of three 25-ton capacity cableways operating from a head tower on the left abutment to blanket the whole dam structure, except a portion of the left abutment and part of the power station structure. A fourth cableway of 20-ton capacity operated downstream from the main cableway system to handle the construction of the rest of the dam structure and the power station. The three main cableways were able to handle about 7200 cubic yards of concrete in a twenty-hour day.

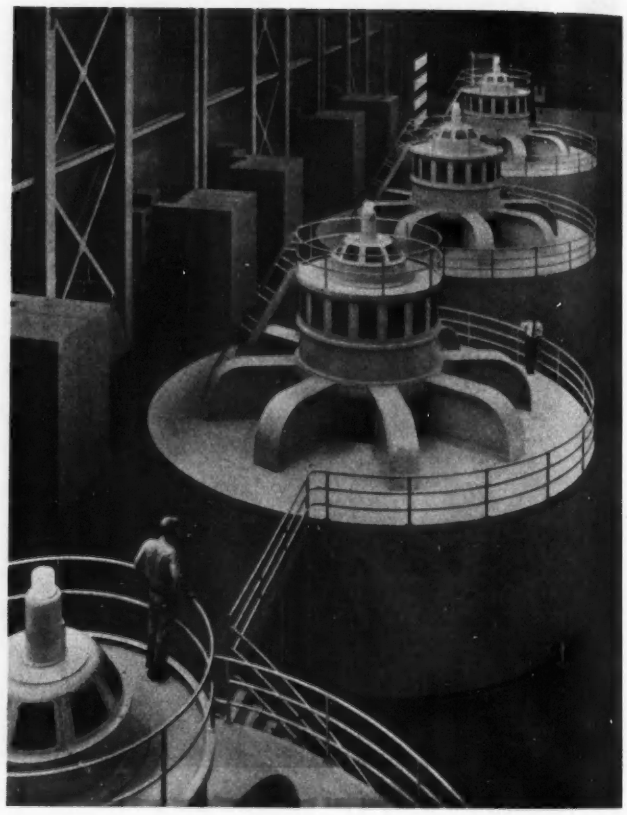
Cableway buckets of several designs were used for different classes of concrete placement. The bulk of the concrete for the dam structure was handled in 8 cubic yards buckets, square in cross-section, and suspended from the cableway by two sets of sheaves. The sheaves carried brackets attached to the sides of the bucket and the bucket gate releases. By shifting the load from one set of sheaves to the other the bottom-dump-gate openings were controlled. A safety-trip release operated manually at the point where the concrete was to be placed prevented accidental unloading in transit. The concrete placement was regulated to provide a maximum differential of 30ft between adjacent blocks and 40ft between the highest and the lowest blocks in the dam. Concrete placement in any block was not allowed to exceed a rate of 5ft of depth in seventy-two hours.

All horizontal surfaces to receive concrete were given a coating of mortar. The water-cement ratio of the mortar was not permitted to exceed that of the concrete to be placed on it. The mortar was mixed in the main mixing plant and transferred to the placement area in an 8 cubic yards bucket. It was broomed across all horizontal surfaces before the regular concrete was placed. Mass concrete was placed in successive layers of approximately 20in thickness for the full width of the block. Placement was started at the downstream end and proceeded upstream only far enough to allow successive 20in layers to be applied until the full 5ft height of the restricted placement area was reached. The slope of the unconfined upstream edges of the successive layers of concrete was regulated to minimise segregation and to secure adequate compaction without unnecessarily enlarging the area of exposure of the fresh concrete. The placement of additional concrete was carried forward toward the upstream end of the block in similar progressive stages to the full area of the block. Each layer of concrete was worked to a satisfactory density by teams using two-man pneumatic vibrators. A one-man pneumatic auxiliary vibrator was used for consolidating concrete in small or inaccessible areas. All concrete surfaces were kept moist for twenty-one days, or until covered by fresh concrete.

The climatic conditions at the construction site were such that concrete placement was stopped during the winter months. From about the middle of November to the middle of March each year all construction activities were reduced to a minimum with only drilling, repair and maintenance, and other incidental work being carried on. During this time the contractor established a rule of "no work" when the temperature at 8 a.m. was below 0 deg. Fah. As an example of the effect of this rule, during January, 1949, the contract was completely shut down about half of the time.

The Hungry Horse scheme was designed and constructed under the direction of L. N. McClellan, chief engineer of the U.S. Bureau of Reclamation, with C. H. Spencer acting as construction engineer. The general construction contract was held jointly by twelve large American civil engineering contractors, known as General-Shea-Morrison.

Overhead conveyor line with aggregate screening plant in background



Interior of power station, showing four 75MVA turbo-generators

Industrial and Labour Notes

National Economy and Export Prices

In the July issue of the *Bulletin for Industry*, issued by the Treasury to provide a monthly review of the economic situation, it is shown that the nation's economy is fully employed. During the opening months of this year manufacturing production was 7½ per cent higher than in the first quarter of 1954, the unemployment rate was down to 1 per cent, and factory building approvals and net new home orders for machine tools were both from 60 to 70 per cent higher than a year earlier. It is pointed out that although the volume of imports has decreased in recent months and import prices have fallen from their February peak, it would not be wise to look solely to a falling import bill to bring about an improvement in the balance of payments. This year there will be heavy additional import commitments for coal, a further loss to the balance of payments from lower coal exports, and steel imports are also heavy. For this reason the aim must be, says the *Bulletin*, to increase the rate of exports, as world trade in manufactured goods is expanding fast. In the nine months ended March last it is estimated that world trade in manufactures was 13 per cent higher by volume than a year earlier.

During the earlier months of this year bigger increases in exports were shown by the United States, Japan and Germany than by this country. During the first nine months of 1954 this country's share in world exports of manufactures was 21 per cent and this figure dropped by 1 per cent in the following six months, equivalent to some £100 million of exports. As the level of costs is crucial in determining the competitiveness of the goods offered overseas, the *Bulletin* points out the importance of matching rising earnings with higher output. For most of the post-war period there had been a general tendency for export prices to rise and to that extent our competitive position had not worsened, but for some time now prices in the United States and in Germany have stopped rising. In this country, however, labour costs in manufacturing appeared to have risen faster than in either the United States or Germany. A warning is given that a significant rise in our export prices at this time could jeopardise our chances of keeping exports rising and so of keeping the economy expanding. Thus, the only way to prevent prices from rising is to match increased income by increased output per man now that there is full employment.

Coal Price Increases

A letter on the subject of the coal price increases recently announced has been sent to the chairman of the National Coal Board by Sir Norman Kipping, the director-general of the Federation of British Industries. The letter stated that the grand council of the Federation was staggered by the scale of increases demanded, which by their sudden introduction would not only handicap competitive power in the heavy fuel and power-using industries, but also entail substantial losses on existing contracts. It went on to point out that no competitive industry could possibly subject its customers to an 18 per cent price increase almost without notice. The proportion of the increase falling in the end upon industry would in a full year reach some £40,000,000. The Federation had been shocked to find in the Board's public announcements so little by way of analysed justification for the increases. The wording of the announcements suggested that some considerable proportion was in anticipation of future expenditures on developments, but the Federation felt bound to say that past programmes of developments and improvements did not appear, at any rate so far, to have justified themselves either in lower costs or in increased output.

The Federation had already requested the Government to conduct a critical analysis of the coal export programme. Some part of that programme was no doubt politically essential, but in any case it was considered deplorable to pare down sales of coal to neighbour countries wanting to buy it, so adding another loss to the balance of payments, and endangering friendly trade relations. The letter went on to say that, as it was, each extra ton exported has now to be replaced by imports costing £2 more. There must, therefore, be a critical scrutiny of the export programme to see where reductions could be made, and until this was done the Federation did not agree that £24,000,000 a year must be collected from home consumers to pay for the extra cost of imports. What the Federation considered more than anything else was basically at fault was the Board's failure to get more coal. The difficulty in increasing mining manpower was appreciated, but an improvement in productivity of a mere 2 per cent a year—a modest enough return for all that had been spent on improvements—would almost completely have avoided shortage over recent years, and with it the heavy bill for imports. In expressing its very strong protest at the latest price increases, the Grand Council of the Federation requested a completely new scrutiny of the whole basis on which they had been calculated.

Effect of Coal Prices on Electricity Charges

A special conference of the members of the Central Electricity Authority and chairmen of the Area Electricity Boards has been held to consider all aspects of the effect on the Electricity Supply Industry of the recent severe increase in coal prices. The text of a statement issued as a result of this conference is reproduced here:

The Central Electricity Authority and the Area Electricity Boards have been trying to build financial stability in a period of continually rising costs of coal, wages, transport, and all things used by the industry. In the process the prices to consumers have been kept within reasonable bounds. The average revenue received per unit for electricity has risen by about 30 per cent over pre-war. By the expansion of the industry, by more efficient plant and more economical operation, surpluses have been earned every year since the industry was nationalised. For the year ended March 31, 1955, there was a net surplus of £8,000,000 (i.e. less than 2½ per cent on annual turnover and less than one half of 1 per cent on the capital employed) after providing £10,000,000 for additional depreciation to meet the cost of replacing assets. Such surpluses are modest in comparison with the scale of operations carried on by the industry. They must be maintained and even increased if financial stability is to be assured, and more money provided to help finance the continuing expansion of the industry. Apart altogether from coal, there have been recent increases of £9,000,000 a year in wages and salaries and £3,500,000 in freight charges, in addition to increased capital charges. It was hoped that the industry could carry these increases without having to raise prices generally to electricity consumers.

The new coal cost increase of some £20,000,000 in a full year now makes this impossible. The coal increase alone would not only wipe out the surpluses but would lead to deficits. Part of the coal cost increase will be recovered automatically from industry by the operation of the "Coal Clause" to industrial and certain other supplies, and domestic, commercial and other classes of consumers must expect to pay their fair share of the increased costs. The Central Authority and the Area Board chairmen have reluctantly concluded that increases in the charges to domestic, commercial and other users must take place and proposals for tariff increases will be submitted to the Authority by the Area Boards accordingly. Following the normal procedure, these proposals will be referred to the Electricity Consultative Councils. The increases will not be uniform over all the Area Boards owing to the varying incidence of the extra costs and the differing tariff structures. These increases will be announced by the Area Boards as soon as possible.

In view of the importance of preserving the national financial position of the industry, the Central Authority considers that, save in exceptional circumstances, the increases should take effect from the beginning of October.

Pig Iron and Steel Production

The Iron and Steel Board has issued figures on the production of pig iron and steel in this country for June and for the first half of the year. Steel production in June averaged 364,200 tons a week, compared with 371,700 tons in June, 1954, and during the first half of the year totalled 10,074,600 tons, compared with 9,524,200 tons in the same period of 1954. Pig iron production in June averaged 216,800 tons a week, compared with 233,200 tons a week in June, 1954. The reduced rate of production as compared with last year in each case resulted from rail and dock strikes. The announcement by the Board says that it is estimated that approximately 150,000 tons of steel and 120,000 tons of pig iron were lost during the second quarter of this year as an immediate result of the rail and dock strikes. The full adverse effects of the strikes may not be manifest for some time, particularly in their impact upon the import of raw materials.

In its annual report the Board drew attention to the difficulties arising from the strain on shipping and unloading facilities in carrying through the heavy programme for the import of the necessary raw materials in 1955. It had been hoped that these would lessen during the summer, but the difficulties have, in fact, been intensified by the continued import of coal, by other abnormal movements of commodities throughout the world, and by the dislocation of shipping programmes by the rail and dock strikes. The resultant curtailment of imports of iron ore during the peak summer period, it is considered, may well involve some check in the expansion of pig iron output next winter expected from the operation of four additional blast-furnaces in the second half of this year. These furnaces have an estimated extra output of 1,000,000 tons of pig iron a year. This check in the expansion of pig iron output may result in steel output during the latter part of this year and the early part of next year being rather less than was at one time thought probable. Nevertheless, there still remains a prospect of producing about 19,500,000 ingot tons of steel in 1955, compared with just over 18,500,000 ingot tons in 1954.

Imports of finished steel averaged 15,100 tons a week during the first five months of the year, as compared with 5900 tons in the corresponding period of 1954. Exports of steel rose from an average of 40,000 tons a week in the first five months of 1954 to 52,000 tons a week in the corresponding period of 1955. This increase was to some extent due to the fulfilment of commitments entered into in 1954 when there was a falling-off in forward ordering by United Kingdom consumers.

Iron and Steel Import Duties

Following consultation with the Iron and Steel Board about the supply position, the Government has decided to make a new order affecting the temporary suspension of import duties on iron and steel. This order prolongs the temporary suspension of import duty on cold rolled steel sheet of a value of less than £80 per ton until September 18, 1956, and suspends until March 18, 1956, the import duties on a wide range of iron and steel products. The duty on most of these, including tinplate and tinned sheets, is already suspended until September 18, 1955. In order to ensure adequate supplies of ferro-manganese for the manufacture of steel in the United Kingdom, it has also been decided to suspend the duty on blast-furnace ferro-manganese until March 18, 1956. So as to ensure that imports of tinplate do not displace the output of the hand mills, the Government has obtained a renewed undertaking from the producers and the main consumers of tinplate that all available home-produced tinplate, including the full output of the hand mills, will be taken up.

Personal and Business

Appointments

MR. G. W. TURTON, M.I.Mech.E., has been appointed general manager of J. H. Humphreys and Sons, Ltd.

THE GENERAL ELECTRIC COMPANY, Ltd., states that Mr. H. H. Hatton has been appointed assistant manager of its Liverpool branch.

MR. J. S. DUMERESQUE, A.M.I.E.E., has been appointed general manager of Semtex, Ltd., a subsidiary of Dunlop Rubber Company, Ltd.

THE NATIONAL COAL BOARD announces the appointment of Mr. J. Murray Grammer as director-general of the purchasing and stores department.

RICHARD SUTCLIFFE, Ltd., Horbury, Wakefield, states that Mr. E. Crome, secretary of the company, has been appointed to the board as financial director.

WILLIAM GEIPEL, Ltd., Vulcan Works, Bermondsey, S.E.1, states that Mr. C. A. Baker has been appointed a service director. Mr. Baker has been in charge of the company's electrical control gear section since 1946.

BABCOCK AND WILCOX, Ltd., announces the appointment of Mr. A. W. Hanson as manager of the Newcastle upon Tyne office. Mr. Hanson joined the firm in 1946 and has been manager of the office in Karachi since 1949.

MR. J. L. A. HARTLEY has been appointed publicity manager of Rotary Hoes, Ltd., Horndon, Essex, in succession to Mr. Peter Finch, who has become general editor of the subscription books division of George Newnes, Ltd.

FOLLOWING the death of Mr. J. J. Conlan, the British Electrical and Allied Manufacturers' Association has appointed Mr. A. W. Bailey, head of the statistical department, and Mr. R. F. Masters, editor of *The Beama Journal*.

MR. B. B. GREEN and Mr. W. J. McBride have been appointed directors of Edgar Allen and Co., Ltd., Imperial Steel Works, Sheffield. Mr. H. R. Burkinshaw has been appointed to the staff of the company's London office.

THE BRUSH GROUP, Ltd., states that Colonel H. T. Thornley, managing director of J. and H. McLaren, is relinquishing that appointment on August 27th to become director of administration and supply at the group's London headquarters.

ALUMINIUM WIRE AND CABLE COMPANY, Ltd., states that Mr. C. H. E. Ridpath, M.I.E.E., chief electrical engineer, has been appointed consulting electrical engineer. He is succeeded as chief electrical engineer by Mr. W. J. Nicholls, M.I.C.E., M.I.E.E.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., states that Mr. E. H. Evans has been appointed chief of the test division in succession to Mr. F. G. Robb, who has retired after thirty-six years in the company's service. Mr. R. E. Burnett has been appointed full time assistant to the general manager of Marconi's Wireless Telegraph Company, Ltd., and his duties as manager of education and technical personnel have been taken over by Mr. E. R. L. Lewis. Mr. R. G. Hulse has been appointed principal of Marconi College. He has been deputy principal for some time.

THE CENTRAL ELECTRICITY AUTHORITY, London Division, announces that, following the retirement of Mr. H. R. London and Mr. W. W. Brown, Mr. M. G. Crockett, M.Inst.F., has been appointed superintendent at the St. Marylebone generating station and Mr. C. E. Sheppard, A.M.I.E.E., superintendent at the Bow generating station. Mr. F. R. R. Jones, D.Sc. (Eng.) Hons., A.M.I.Mech.E., A.M.I.E.E., has been appointed deputy superintendent at the Deptford West generating station, and Mr. A. G. Cox, Assoc.I.E.E., A.M.Inst.F., is taking up appointment as superintendent of the Bankside "A" and "B" generating stations on August 1, 1955.

MR. W. H. R. WEBB has accepted an appointment from the United Nations Technical Assistance Administration as a railway signalling expert to Iran. The appointment, which was made at the request of the Government of Iran, is part of the United Nations programme to assist the less developed countries and areas in their programmes of economic development. Mr. Webb will be in Iran for six months and is expected to take up his duties in Teheran about August 15th. He will make a survey of the signalling systems in use on the Iranian railways with a view towards the improvement of the safety and efficiency of their operation. Following the conclusion of his field work he will prepare a report for submission to the Iranian Government.

Business Announcements

YATES PLANT, Ltd., announces that as from August 15th next all inquiries should be addressed to Whidborne Street, London, W.C.1 (telephone number Terminus 0568/9).

LEYLAND MOTORS, Ltd., has formed a new company for the manufacture in India of vehicles and engines. The new company, Ashok Leylands, Ltd., will be under the chairmanship of Sir A. Ramaswami Mudaliar.

EDWARDS HIGH VACUUM, Ltd., of Crawley, announces that it has formed a subsidiary company in Italy. This company, Edwards Alto Vuoto S.p.A., was formed in conjunction with the Societa Apparecchi Elettrici e Scientifici and has offices in Milan.

WOLF ELECTRIC TOOLS, Ltd., has established a new company in Australia in conjunction with its associate Consolidated Agencies Pty., Ltd. The new company, Wolf Sales Pty., Ltd., will have offices at 122–124, Sussex Street, Sydney, Australia, and its directorate will include Mr. D. K. Nicholas (chairman), Mr. C. F. Macdonald (managing director), Mr. B. E. Nicholas, and Mr. R. F. Hatto.

THE HARGREAVES GROUP OF COMPANIES, has concluded an agreement with the Esso Petroleum Company, Ltd., by which the group has been appointed as distributors of Esso fuel oils over a wide area in the North of England and North Midlands. Fuel oil supplies will be drawn from the refinery at Fawley, and distributed by the group's road tanker fleet to both domestic and industrial premises. Distribution will be controlled from the group head office at The Calls, Leeds, 2.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., announces the establishment of a metals group and the appointment of Mr. W. F. Randall as managing director of the group. The new group, in addition to the new Crawley factory, embraces Telcon-Magnetic Cores, Ltd., at Chapelhall, Lanarkshire; Temco, Ltd., at Lydbrook, Gloucestershire; Sankey-Telcon, Ltd., which operates at Crawley; and the recently acquired Magnetic and Electrical Alloys, Ltd., at Burnbank, Hamilton.

Contracts

BAIRD AND TATLOCK (LONDON), Ltd., announces the receipt of a contract for £20,000 to supply scientific instruments and apparatus for agricultural laboratories in Yugoslavia.

DECCA RADAR, Ltd., has been awarded a contract for the installation of an airfield control radar, type 424, at Dum Dum Airport, Calcutta. This equipment, which is to be used as an approach aid, is expected to be in operation by the autumn.

THE GENERAL ELECTRIC COMPANY, Ltd., has received an order from the London Transport Executive for thirty-two 575V traction motors to equip three prototype tube trains of steel construction with aluminium panelling, and incorporating rubber in the suspension. The motors will be generally similar to the LT100 design, but slightly smaller and lighter. They will be self-ventilated four-pole machines with roller armature bearings and roller bearings in the axle suspension sleeve. Transmission will be through "Wiseman" gears with a ratio of 18/65.

Miscellanea

R.E. TRANSPORTATION CENTRE OPEN DAY.—We are informed by the commandant of the Transportation Centre, Royal Engineers, at Longmoor, Hants, that the centre will be open to the public from 1.30 p.m. to 7.30 p.m. on Saturday, September 3rd. During this day there will be displays and demonstrations showing the full range of military transport, and also an exhibition of engineering plant. The demonstrations and exhibit shown will include prefabricated plate-laying, mobile railway workshops, the railway signalling school, port operating, diving, a movement control model room, &c.

EXHIBITION OF ELECTRICAL STANDARDS AND METERING.—A special exhibition dealing with electrical standards and metering has been opened at the Science Museum to coincide with the current meeting of the International Electrotechnical Commission. Although the exhibition is of particular interest to those concerned in the problems of metering bulk supplies of electrical energy to large industrial and commercial undertakings, it is intended also for the less specialised visitor and serves to demonstrate the care taken in the accurate calibration of electricity meters. One of the objects of the exhibition is to show the origin and derivation of the various electrical units. An exhibit of particular interest is the complete set of the original B.A. Units of Resistance, which was made in 1864 for the British Association and constitutes the oldest set of accurate electrical standards now in existence.

CERTIFICATE OF GAUGE AND TOOL DESIGN AND DRAUGHTSMANSHIP.—For some years, the Gauge and Tool Makers' Association has operated a scheme for award under certain terms and conditions of a certificate of craftsmanship. The object of the award is to provide an incentive for young men whose ambition is to become really skilled tool-makers rather than to attain administrative or executive positions in industry. The Association has now decided to introduce another award in the form of a certificate of gauge and tool design and draughtsmanship, to provide a similar incentive for young men who wish to become skilled gauge and tool draughtsmen and designers.

DIESEL TRACTION SCHOOL AT DERBY.—A new school, forming part of the London Midland Region motive power department organisation for the training of motive power staff in the maintenance and operation of diesel traction, has been opened at Derby. At this school district officers, shedmasters, foremen, inspectors, fitters and drivers from all parts of the London Midland and other Regions will attend a two weeks' intensive course to qualify them before diesel trains are brought into operation in their areas. The school is equipped with models and diagrams and lectures will be given by two qualified instructors. Drivers attending the school will be taken on experimental runs in the Derby district on the new diesel railcars to gain experience in the handling of the controls and the general operation of the units.

LONGEST GAS GRID IN BRITAIN.—The final link in the first 1000 miles of new main laid by the South Western Gas Board since nationalisation was coupled up by Sir Harold Smith, Chairman of the Gas Council, at Beacon Hill, near Shepton Mallet, on Tuesday, July 19, 1955. This main will eventually be the longest gas grid in the country, from Evesham in Worcestershire, to Penzance in Cornwall, covering some 8400 square miles. The scheme, when completed, will result in the closing down of all the small and uneconomic works in the south-west, leaving sixteen major manufacturing stations to serve the area. Since nationalisation, forty-five small works have been closed down by this board and fifteen more will be closed by March, 1956. During the same period a gas supply has been made available to ninety-one new centres of population and the main laying scheme will eventually take in a further 210 centres within the next two or three years.

SAFETY AND HEALTH IN INDUSTRY.—A booklet serving the dual purpose of a buyers' guide on industrial safety equipment and a handbook on general safety and health for all those engaged in industry has been published by Sky Press, Ltd. It is entitled "Safety and Health in Industry" and shows the many types of factory accidents which can befall the worker in industry. One of the main sections is on the guarding of machinery and the many accident groups connected with machinery are illustrated and captioned with safety hints. Other articles include guidance regarding the safe use of tools, the role of protective clothing and the right way to ackle power and manual handling, lifting and stacking. Safety officers and indeed all concerned with industry, are likely to find this booklet of interest; copies may be obtained—free of charge—from the Director, Industrial Health and Safety Centre, 97, Horseferry Road, London, S.W.1.

MEASUREMENT WITHOUT TOUCH.—Particulars have been received of an interesting method of testing sensitive photographic plates for flatness, without exposing them to light or touching the surface to be measured, developed by the metrology division of the National Physical Laboratory. For this purpose an experimental pneumatic gauging apparatus was designed. In it the plate is placed with the emulsion coated side downwards to rest on three balls which are outside the picture area and thus do not damage the emulsion. Six jets of air are then projected upwards against the plate at a pressure of less than ½ lb per square inch and the pressure variations are shown by changes of level of coloured water in six vertical glass tubes. The magnification of the apparatus is 2500 and the columns are calibrated in microns, so each division represents about 0·00004in. The gauge works off a normal factory air supply through a pressure-regulating valve so that its readings are not affected by changes of supply pressure. It also has the considerable advantage that its readings are not affected by temperature. The gauge can be adapted for other flatness tests or for testing the contours of complicated shapes by arranging jets at different heights to blow at points where it is required to explore the surface.

LARGE HANGAR DOORS.—At the Ministry of Supply Establishment at Boscombe Down a weighbridge hangar has been built for the weighing and calibration of new aircraft. It has doors measuring 297ft in width and 67ft in height, which are stated to be second only in size to the Bristol "Brabazon" hangar doors. The hangar is fitted with doors at both ends, and each consists of two parts which can be operated to open either from the centre to the sides, or from the sides to the centre. The motive power for the movement of each door is supplied by four 5 h.p., three-phase motors operating at 400V a.c. Current is picked up from three grooved copper trolley wires by miniature current collectors fitted with carbon insert slipper heads. The wires are approximately 300ft long and are supported at intervals of 34ft from insulated supports and 3½in mechanical ears. Porcelain insulation has been used throughout. The wires have been erected at a tension of 550 lb at 60 deg. Fah. and are fed with alternating current at one end by means of 0·0225 square inch V.R.I. cables. The doors were designed, manufactured and erected by Esavian, Ltd., of Stevenage, Herts, and the installation of the B.I.C.C. current collection equipment was carried out by British Insulated Callender's Construction Company, Ltd.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

MINING ENGINEERING

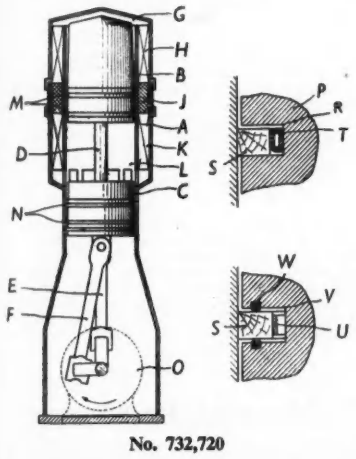
725,611. May 11, 1953.—MAINTAINING AND RESTORING THE PRESSURE IN OIL AND GAS FIELDS, Union Rheinische Braunkohlen Kraftstoff Aktiengesellschaft, Wesserling, Germany, and Otto Kriegbaum, 68, Ludwigstrasse, Fürth (Bavaria), Germany.

In our note on this specification in the issue of April 22nd last it was implied that the main purpose of this invention was to clean oil wells. Actually its purpose is to increase the output of oil by the pressure produced by inert gas, generated by combustion, which advances to the place at which the oxygen-containing gases necessary for the combustion are introduced to the outlet point for the oil. This inert gas, which is generated in the well, is quite distinct from that introduced in the preliminary cleaning operations described in our note. The specification describes a process and equipment whereby the pressure in oil and gas fields can be maintained or restored by generating an inert gas in the productive formation by combustion of natural gas or oil with oxygen containing gases. The inert gas generated forces the oil to the surface by gas lift. The term "inert gas" is used to denote gases which are free or substantially free from oxygen and therefore non-reactive to natural gas so that fire and explosion hazards are safely avoided. The means are described for supplying compressed oxygen containing gases to the formation under carefully controlled conditions to eliminate any fire and explosion risk.

HOT GAS ENGINES

732,720. September 11, 1952.—HOT GAS RECIPROCATING ENGINES OR REFRIGERATORS OR HEAT PUMPS, N.V. Philips' Gloeilampenfabrieken, Emmasingel 29, Eindhoven, Holland.

The invention relates to hot gas reciprocating engines and refrigerators and heat pumps, operating according to the reversed hot gas reciprocating engine principle. It has now been found that even in high-speed engines operating, for example, at a speed of 1500 to 2000 r.p.m., wooden piston rings, which need not be lubricated, may be substituted for metal ones. The drawing shows a refrigerator made according to the invention comprising a displacer with wooden piston rings. The right-hand view shows parts of two arrangements of a wooden piston ring and a displacer on a larger scale. The refrigerator comprises a cylinder *A* in which a displacer *B* and a piston *C* reciprocate with a contant phase difference. The displacer is connected by a connecting-rod mechanism *D* and *E* to the crankshaft, the piston *C* being coupled through a connecting-rod *F* to another crank of the crankshaft. The space *G* above the displacer is the freezing space of the refrigerator and is connected through a freezer *H*, regenerator *J* and cooler *K* with a space *L* between the displacer and the



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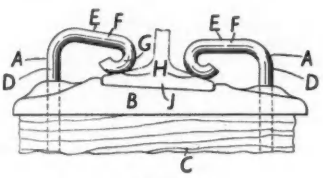
piston, this space being the cooled space. The rod *D* is rigidly secured to the displacer and is guided to perform a reciprocating movement relative to and through the piston. In this arrangement substantially no transverse forces act on the displacer, so that the displacer may be equipped with wooden piston rings *M*. The piston is provided with normal metal piston rings *N*, since the transverse forces acting on the contact surface of this piston are considerable. The piston rings in the displacer need not be lubricated so that no means are required for conveying lubricant to them. The refrigerating apparatus is driven by an electric motor *O*. The upper right-hand view shows part of a cross-section of the displacer. The displacer body *P* is furnished with a slot *R* accommodating a wooden piston ring *S*, which engages the cylinder wall. Since the piston ring itself lacks sufficient elasticity, a rubber ring *T* is provided behind the piston ring, and by this rubber ring the piston ring is expanded, being split for this purpose. The rubber ring is initially circular in cross-section, although it may alternatively have different initial cross-sections, such as a rectangular cross-section. The rubber ring *T* also prevents excessive leakage of working medium past the piston ring. The lower view shows a modified construction in which an expander spring *U* is provided behind a wooden piston ring *S* so that it is urged outwards. The piston slot *V* is itself provided with annular slots *W*, each accommodating a rubber ring. By this construction excessive leakage of working medium past the ring *S* is avoided. This construction is particularly suitable for use in refrigerators in which considerable contraction of the ring occurs. A laminated wooden piston ring is also shown in the specification.—*June* 29, 1955.

RAILWAY ENGINEERING

732,536. November 8, 1951.—RAILWAY RAIL SPIKES, Elastic Rail Spike Company, Ltd., a British company, Cory Buildings, 117, Fenchurch Street, London, E.C.3. (*Inventor: Leopold Stewart Sanson.*)

The invention relates to rail fastenings and is concerned with elastic rail spikes, and an object is to devise a rail fastening which will permit speedy removal of the rail from the fastening. Referring to the drawing, the rail fastening includes spikes indicated generally by *A*, and a base plate *B* on a sleeper *C*. Each spike has a shank portion *D* extending through an aperture in the base plate into the sleeper. Each spike is made from circular section spring steel, heat-treated, and has a head portion, indicated generally by *E*, which extends laterally from the shank. The head portion curves away from the axis of the shank



No. 732,536

through an angle greater than 90 deg., when the spike is undriven as shown on the left-hand side of the drawing, and then continues as a rectilinear portion *F*. The free end part of the head portion terminates in a curved part *G*, which subtends an angle greater than 180 deg. and which lies beneath the end of the rectilinear portion *F*. The exterior of the curved part at the lower side is flattened at *H* and bears elastically upon the rail base *J*. The flattening of the spike at the location *H* increases the area of contact between the spike and the rail base and increases the creep-resisting properties of the fastening. The spike is driven into the sleeper until the rectilinear portion *F* becomes substantially at a right angle to the shank *D* as shown on the right-hand side of the drawing. The spike thus acts as its own driving gauge. The fastening as described affords the advantage that the rail is readily releasable from the fastening without the necessity of withdrawing, partly or wholly, the spikes from the sleeper. A simple lever can be employed for releasing the fastening from the rail. This lever is described in the specification, together with a second form of rail fastening.—*June* 29, 1955.

GAS TURBINES

732,745. June 16, 1953.—GAS TURBINE PLANTS, Sulzer Frères Société Anonyme, Winterthur, Switzerland.

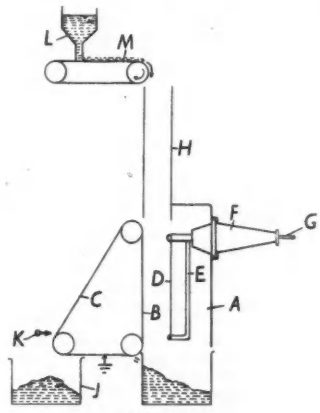
The invention relates to a gas turbine plant with a combustion chamber in which combustion of the fuel takes place in the presence of an additive which besides having the property of reducing harmful effects of combustion products also has the property of accelerating combustion. The dimensions of the combustion chamber are such that the value of the combustion chamber loading is at least 3,000,000 kg calories per kilogramme per cubic centimetre of the absolute pressure prevailing in the combustion chamber per hour per cubic metre of the combustion chamber.

The advantages achieved are considerable, as, for example, in a gas turbine power unit for an aircraft employing a high-grade fuel which burns rapidly it is possible for complete combustion to be achieved in a comparatively small combustion chamber, the numerical value for which may exceed 10,000,000. On the other hand, in large size static power plants where low-grade slow-burning fuels are burnt, the permissible value of the combustion chamber loading will in general be only about 1,000,000 if complete combustion is to be achieved. The low grade fuel is often such as to require the use of an additive for reducing the harmful effects of the combustion products, and the applicants have found that if the additive is chosen so that it also acts as a combustion accelerator, the combustion chamber loading can safely be increased to at least 3,000,000. Under certain circumstances a loading value may be employed which would otherwise only be permissible with a high-grade fuel such as is used for aircraft, that is, a value of 10,000,000 or even more. Thus, by the invention, the dimensions of the combustion chamber can be reduced to such as extent that its volume is reduced to less than one third of that which would otherwise be necessary, and in some cases even down to below one tenth of that volume. In this way not only is space saved, but there is also a considerable saving in weight and cost and also in heat losses. A further important advantage is that the energy content of the combustion chamber is kept to a small value, which reduces the inertia of the plant to the regulating operations and also reduces losses which occur when the load on the plant fluctuates.—*June* 29, 1955.

ELECTRICAL ENGINEERING

729,934. August 14, 1952.—ELECTROSTATIC SEPARATION, Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 1–3, St. Paul's Churchyard, London, E.C.4. (*Inventors: Eric Russell Fisher and Frank Waterton.*)

The invention aims to provide an improved method and apparatus for separating relatively thin small laminæ of mica or other material from a mixture containing such laminæ together with other dielectrically similar small laminæ of greater thickness and/or density (such greater density being due, for instance, to the inclusion of dirt in the laminæ). Referring to the drawing, a precipitator unit comprising a container *A* for a high-voltage corona discharge system has at least one vertical wall *B* of the container formed by a portion of continuous conveyor belt *C* arranged as shown. The belt *C* is made of or covered with electrically conducting material and is earthed to form a low potential electrode. Within the container *A* and opposite the vertical portion of the belt *B* is arranged a vertical wire *D* or other corona producing electrode supported on a framework *E*, which is in turn supported from an insulator *F* extending through another wall of the container and carrying a lead-in conductor *G* for supplying a high potential to the wire *D*. When energised, this wire *D*, in conjunction with the earthed conveyor belt *C*, constitutes a corona system in which a transverse electrostatic field is set up between the wire *D* and the belt *C*. A vertical pipe or chute *H* is arranged above the precipitator unit in such



No. 729,934

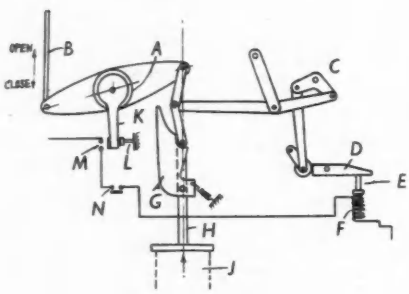
position that when in use the mixture to be sorted is allowed to fall down the chute, it passes out of the lower end into the region of the electrostatic field where the components of the mixture receive a charge. The length of the chute *H* is such that by the time the mixture reaches the electrostatic field the velocity of the relatively thin laminæ in the mixture is less than half that of the other components. These thin laminæ are therefore deflected towards the vertical position of the conveyor belt *C*, where they are held by their charge, while the thicker laminæ and any dirt, having a greater velocity, pass through the field with little deflection and fall to the bottom of the precipitator unit, as indicated. The thin laminæ held on the belt are conveyed to the outside of the container, where they drop into a hopper *J*. The laminæ may fall from the belt merely by the action of gravity, but more usually they will

be removed from the belt either by a suitably located mechanical brush or, preferably, by an ionising field for dissipating the charge on the laminæ on the belt; thus an electrical brush, indicated at *K*, may be arranged to apply a reverse electrostatic charge or an alternating ionising potential to the laminæ. In order to make the process continuous the mixture to be sorted may be fed from a hopper *L* on to a second horizontal conveyor belt *M* and thence into the upper end of the vertical chute *H*.—*May* 11, 1955.

ELECTRICAL ENGINEERING

731,280. July 21, 1952.—POWER ACTUATED AIR OR OIL CIRCUIT BREAKERS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: Cecil Alfred Charles Hillyer.*)

The invention relates to an air or oil circuit breaker having a main contact operating member moved to its closing position by power actuation of a mechanism, and having a trip coil associated with a prop backing up the mechanism, wherein a control contact in the circuit of the trip coil is arranged to be closed for energising the trip coil, removing the prop and collapsing the mechanism, when a predetermined slight reverse movement of the main contact operating member occurs. The drawing shows a schematic arrangement of the linkage between the prime mover and the main shaft of the closing mechanism. The main shaft *A* of the closing mechanism is shown in the circuit breaker closed position, the rod *B* being the connection to the moving contact (or linkage associated therewith) of the breaker. In this condition the trip free mechanism shown generally at *C* is held by the prop *D*, which is connected with the armature *E* of the trip coil *F*. A latch *G* is arranged to support the rod *H* which is directly actuated from the prime mover *J*, which, as already stated, may be springs, a solenoid or a compressed air motor. The latch *G* prevents the main shaft *A* and its related contact from



No. 731,280

making any reverse motion away from the fully closed condition. Consider the effect if some mechanical aberration of the latch, which causes it to fail to latch fully the rod *H* and thereby allow a reversal of motion of the rod, the main shaft *A* and the moving contact should occur. To detect such a reversal of motion an arm *K* frictionally driven from the main shaft *A* is provided. When the breaker closes, rotation of the main shaft is anti-clockwise and the arm *K* is driven into abutment with a stop *L*, the arm *K* being caused to slip through its frictional drive. Upon any reversal of motion, however, the arm *K* will move clockwise with the main shaft *A* and bridge the control contacts *M*. The auxiliary contacts *N* are, as is usual, closed before the main circuit breaker contacts, and should reversal of motion occur with the subsequent closure of contacts *M* then the trip coil will be energised causing the prop *D* to be removed and the full energy of the opening mechanism of the breaker to open the contacts at full rated speed, thereby obviating the serious consequences normally attendant upon failure of the latch following a closing operation.—*June* 8, 1955.

INTERNAL COMBUSTION ENGINES

732,944. June 25, 1953.—CYLINDER LINERS, John William Howlett, and Wellworthy Limited, both of Radial Works, Stanford Road, Lymington, Hampshire.

The object of the invention is to reduce corrosion by casting a coating of aluminium or an aluminium alloy, preferably commercially pure aluminium, over the outside surface of the ferrous metal liner after the surface has been first treated to produce an aluminium-iron alloy layer providing a good bond. The application of the aluminium coating may be carried out by the process known commercially as the "Al-Fin Process" as described in Specifications Nos. 599,684 and 606,330.—*June* 29, 1955.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

ELECTRICAL PERFORMANCE OF ROTATING ELECTRICAL MACHINERY

No. 2613 : 1955. Price 7s. 6d.—The four principal standards relating to the electrical performance of rotating electrical machinery, namely, B.S. 168, B.S. 169, B.S. 225, and B.S. 226, have been revised and combined into a single British Standard, B.S. 2613, which covers all types of machines rated from 1 h.p. per 1000 r.p.m. upwards. To conform to present-day practice a number of significant changes have been made, the most important of which is the recognition of the continuous maximum rating for all motors whether a.c. or d.c. which exceed 50 h.p. per 1000 r.p.m.

Open, protected and pipe-ventilated motors which are rated at not more than 50 h.p. per 1000 r.p.m. continue to be specified on a load-with-overload basis, but the foreword to the standard draws attention to the fact that this anomaly will disappear with the next revision, which will coincide with the introduction of a revised classification of insulating materials. It is expected that the classification will be finalised within about twelve months. In the meantime the continuous maximum rating of these smaller motors is recognised as a matter for special arrangement between the parties concerned. The tables giving details of permissible temperature rise have been completely recast, and for each type of winding a method of temperature measurement is now specified. The various requirements pertaining to electrical performance are stated and the tests required, to demonstrate that the performance requirements are achieved, are specified.

FINE RESISTANCE WIRE FOR TELECOMMUNICATION AND SIMILAR PURPOSES

No. 1117 : 1955. Price 2s.—This British Standard, which supersedes the War Emergency edition of 1943, applies to wires of circular cross-section and of diameters in the range 0·0005in to 0·012in inclusive. It covers four classes of metallic resistance materials, based on the requirements of temperature coefficient of resistance, working temperature and non-tarnishing characteristics. It was considered impracticable to include resistance tables for the large range of materials covered by the scope of this standard, but requirements are stated for the tolerance on resistivity, resistance and uniformity of resistance. Maximum values for the temperature coefficient of resistance over given temperature ranges are specified for each of the four classes of resistance materials. Requirements are also laid down for the physical condition of wires as supplied by the manufacturer, and a mechanical test is specified for wires which are not ordered to a special temper by the purchaser. This standard is complementary to B.S. 115 : 1954.

Technical Reports

Flameproof Electrical Apparatus: Flanged Joints, 1in in Radial Breadth in Mixtures of "Standard" Town's Gas and Air (Ref. G/T298). By T. J. A. Brown, B.Sc., A.Inst.P., and N. Simpson. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 7s. 6d.—For explosive mixtures of "standard" town's gas and air, ignited in a bronze sphere having horizontal equatorial flanges 1in in radial breadth, the most inflammable internal mixture is that containing 18·5 per cent of town's gas by volume. The most readily ignitable external mixture contains 17·0 per cent of standard town's gas. With this combination of internal and external mixtures, the maximum experimental safe gap, M.E.S.G. on a criterion of $n=20$, $k=0·001$in, is 0·024in, and the statistical maximum safe gap, reassessed, S.M.S.G.(R.) is 0·018in.

Maximum Experimental Safe Gaps: A Note on the Emission of Flame Through Flange Gaps (Ref. G/T299). By T. J. A. Brown. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey.—Price 4s. 6d.—The fundamental difference between the British and American tests on flameproof equipment is the criterion of flameproofness: the non-appearance of flame external to the apparatus is the American criterion, whereas in Britain the non-ignition of an external mixture is the standard adopted. The tests described in this note illustrate the difference between the two standards.

The Onset of Breakdown in Gases Subject to Superposed Microwave and Unidirectional Electric Fields (Ref. L/T295). By W. A. Prowse, Elizabeth Laverick and W. Jasinski. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 7s. 6d.—A full description is given of the development of apparatus and technique required to determine the relation between breakdown stress and time of application: the present results indicate that the value of breakdown stress in polyatomic gases is determined in a time too short for the diffusion theory to apply, extension beyond 2 microseconds being required.

The apparatus enabled an auxiliary field to be developed at right angles to the microwave electric stress in a cylindrical resonator operating in the H_{011} mode. Electrons were introduced into the strongest position of the electric field by a naked spark derived from the operating pulse.

Air-Blast Circuit Breakers: A Statistical Study of the Variation in Performance in Repeat Tests of a Single Break Experimental Unit with Axial Blast (Ref. G/T288). By F. Oliver Mason, B.Sc.(Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 10s. 3d.—This report continues the study (THE ENGINEER, December 2, 1949, Vol. 188, pages 630–633) of variation in repeat tests experienced with an experimental air-blast breaker at the E.R.A. Laboratory, and describes the form of distribution obtained from a large number of tests at blast pressures below the working pressure for the circuit in question.

The Effect of Series Resistance on the Characteristics of Capacitative Spark Discharges (Ref. G/T293). by H. G. Riddlestone, B.Sc.(Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 10s. 6d.—The work described in Refs. G/T253 and G/T278 has been continued in this report. A new technique of measurement involving the use of a potential divider has enabled discharge characteristics and discharge energies to be measured over a range of circuit resistance up to 38,000 ohms and for discharges with durations as short as 8×10^{-8} sec. When the spark-gap is fitted with tungsten electrodes, the discharge energy decreases with increase in resistance over the whole range of resistance, but with steel electrodes the energy increases again for resistances above 11,000 ohms. For resistances between 200 ohms and 11,000 ohms the discharge energies are greater for tungsten electrodes. There is a slight knee in the discharge energy resistance curve at the value of resistance which corresponds to the minimum discharge duration.

Launches and Trial Trips

CHARLES H. MERZ, self-trimming collier; built by Hall Russell and Co., Ltd., for the Central Electricity Authority; length between perpendiculars 323ft, breadth moulded 43ft 3in, depth moulded 20ft 3in/25ft 9in, deadweight 3700 tons; four holds, steam deck machinery; "North Eastern Reheat" direct acting triple expansion steam engine, 1475 i.h.p. in service, superheated steam at 220 lb per square inch supplied by two oil fired cylindrical boilers. Launch, June 23rd.

HERMES, oil tanker; built by the Blythswood Shipbuilding Company, Ltd., for Brunsgaard, Kiosterud and Co.; length between perpendiculars 510ft, breadth 68ft, depth moulded 38ft, deadweight 16,300 tons; nine centre tanks and twelve wing tanks, two cargo pump rooms, four 400-tons per hour cargo oil pumps; trial speed 14¾ knots; Rowan-Doxford two-stroke opposed piston oil engines, five cylinders 700mm diameter by 2320mm combined stroke, 6200 b.h.p., two single ended Scotch boilers. Trial, July 5th.

HARPULA, oil tanker; built at Belfast by Harland and Wolff, Ltd., for Shell Tankers, Ltd.; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons; thirty three cargo oil tanks, one cargo pump room; two 550kW turbo-alternators, one 200kW diesel driven alternator; one set of double reduction geared turbines of 7500 s.h.p. taking steam at 500 lb per square inch and 800 deg. Fah. from two Babcock and Wilcox watertube boilers. Launch, July 6th.

RED HACKLE, trawler; built by John Lewis and Sons Ltd., for the Iago Steam Trawler Co.; length between perpendiculars 135ft, breadth 26ft 6in, depth 13ft 3in, electric windlass and electric trawl winch of 1200 fathoms of 2¾in warp capacity; fish room 9300 cubic feet; diesel driven trawl winch generator; British Polar diesel engine, five cylinders, 800 b.h.p. at 250 r.p.m. Launch, July 7th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INSTITUTION OF CIVIL ENGINEERS

Thurs., July 28th.—MIDLANDS ASSOCIATION: Joint Meeting with the Institution of Municipal Engineers, East Midland District, at Nottingham.